EXCLUSIVE BRANSON VS MUSK

VIRGIN & SPACEX BOSSES REVEAL RED PLANET PLANS

All About Space™

NEW FIGHT FOR MARS

Super rockets, colonisation plans and Stephen Hawking on who he thinks will win

"Musk can have the west, we'll have the east"
Richard Branson

"Technology isn't really Branson's whack, y'know"
Elon Musk

WIN £3000 ASTRONOMY KIT

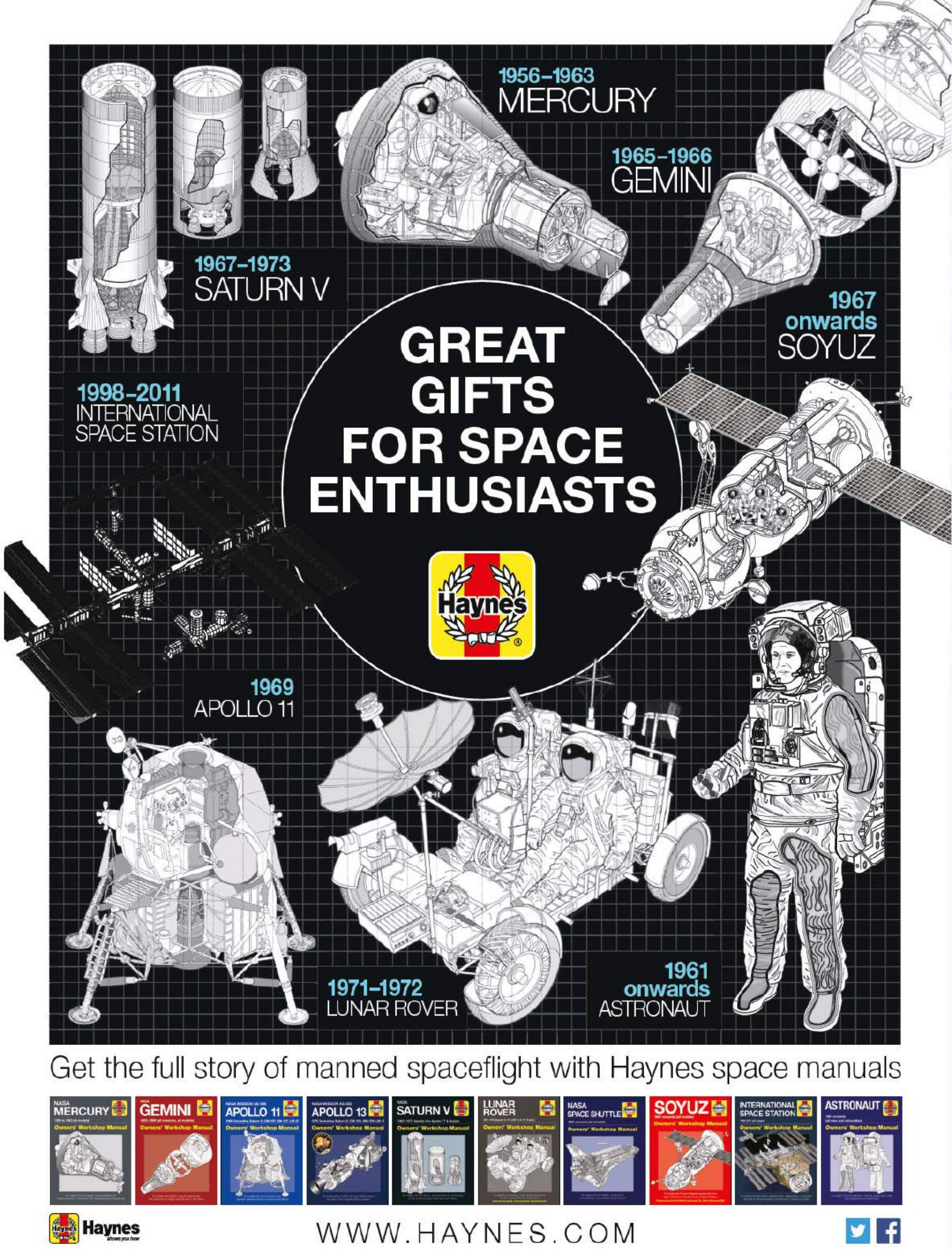
Brian Cox, Bill Nye & more on

THE NEXT BIG BREAKTHROUGHS

Future
ISSUE 073

15 TED TALKS YOU NEED TO WATCH

+ HOT PRODUCTS 2018 • SUBARU TELESCOPE USER MANUAL • **OUR WEIRD MILKY WAY** • TITAN DRAGONFLIES



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Our galaxy is the only one we can study from the inside

Welcome

Did you know that the Milky Way is actually pretty weird? As you'll discover this issue, astronomers have found that our home galaxy isn't like the other galactic structures in the cosmos - and they're very worried. Turn to page 40 for the latest findings from our brand new surveys.

You may have just seen in 2018 with the popping of champagne corks, party poppers, food and balloons, but this month, we're looking even further ahead to the discoveries we're likely to be making in the next decade or so. We had the likes of physicists Jim Al-Khalili, Brian Cox and futurist Michio Kaku on hand to reveal what they'll (hopefully!) be looking forward to when the 2030s roll around.

We love revealing the latest, inspiring new information about the universe along with the new innovative plans for space exploration and this month is no exception - head to page 58 for our pick of the very best TED talks that you really need to watch. We can guarantee you'll be inspired!

This month, we've also rounded up the space and astronomy products you've just got to buy this year - from taking you to the next level in astronomy to the best guides money can buy - there's something for all levels of astronomer.

Before I sign off, don't forget to enter to win £3,000-worth of astronomy kit, and we hope you enjoy your free posters!

Gemma Lavender
Editor

> "We use the Milky Way as a yardstick for the rest of the universe. If it's not typical then we need to know" **Marla Geha, page 40**

Our contributors include...

Colin Stuart
Astronomer & author
According to recent research, the Milky Way isn't like any other galaxy we've ever come across before. Colin finds out what that means for our current theories.

Libby Plummer
Science and technology journalist & writer
Libby's got some ideas worth spreading this issue, with a pick of the very best space TED talks. Head to page 58 and be sure to watch them now!

Lee Cavendish
Staff Writer & astronomer
Lee uncovers what the world's most influential scientists think will be the next big breakthroughs – if it all goes to plan we may crack big mysteries.

Stuart Atkinson
Astronomer & science writer
Stuart provides your guide on this month's planets and the deep-sky targets you should be observing during the first month of the new year.

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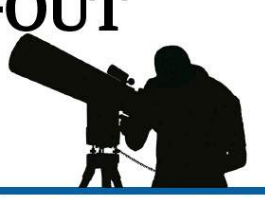
Map of Mars & Messier Marathon



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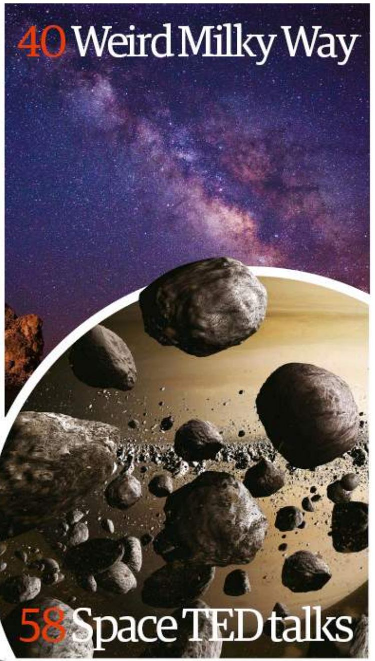

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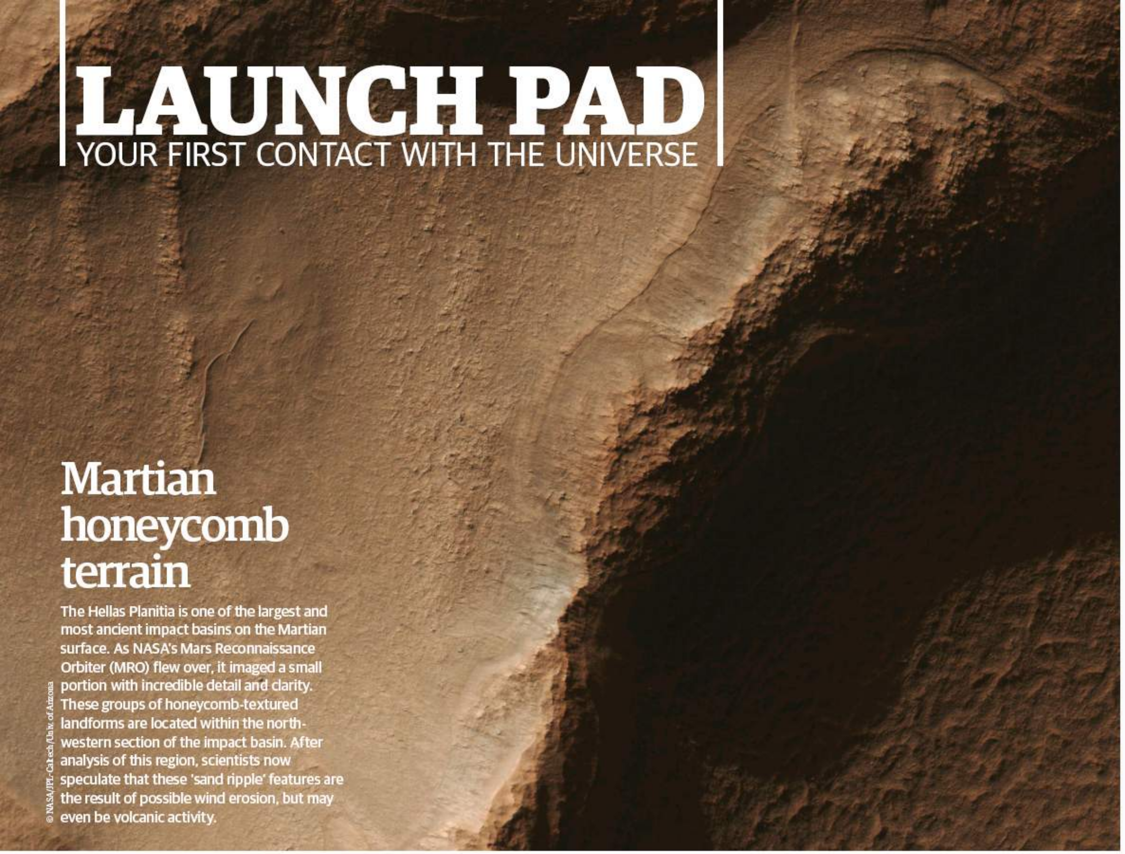


Martian honeycomb terrain

The Hellas Planitia is one of the largest and most ancient impact basins on the Martian surface. As NASA's Mars Reconnaissance Orbiter (MRO) flew over, it imaged a small portion with incredible detail and clarity. These groups of honeycomb-textured landforms are located within the north-western section of the impact basin. After analysis of this region, scientists now speculate that these 'sand ripple' features are the result of possible wind erosion, but may even be volcanic activity.

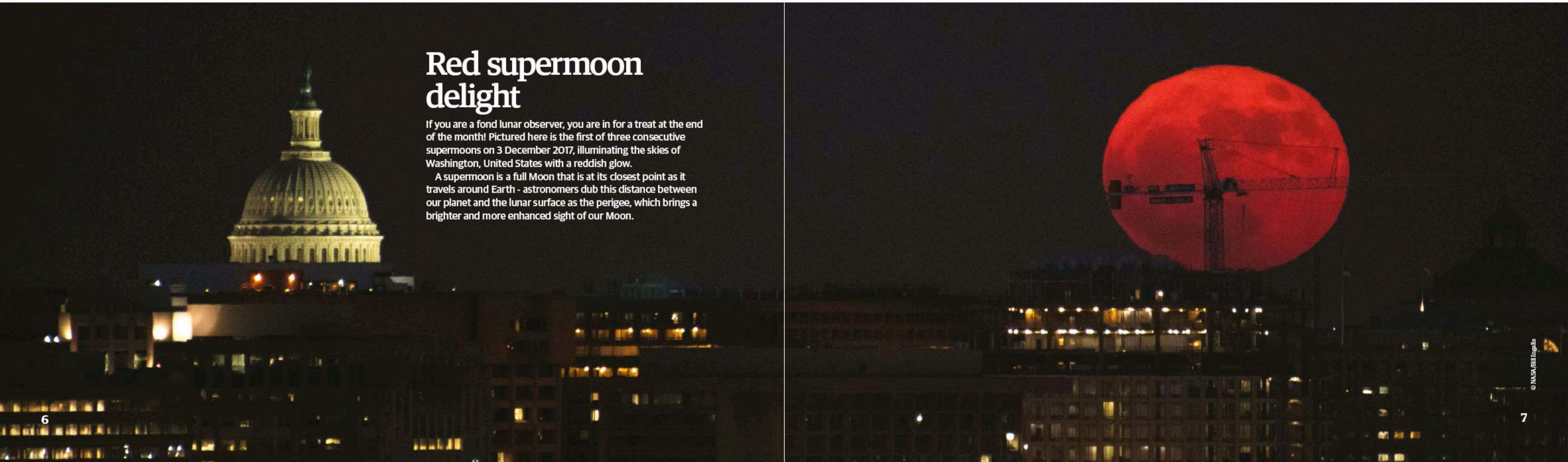
© NASA/JPL-Caltech/Univ. of Arizona

Testing the tools of tomorrow

For five days in November 2017, the Pangaea-X test campaign tested potentially vital tools to see if they could be used on future space exploration missions. This was intended to bring together geology, high-tech survey equipment and space exploration in an international collaborative effort.

In this particular activity, ESA astronaut Matthias Maurer and ESA spacewalk instructor Hervé Stevenin were testing NASA replicas of the sampling tools used on the Apollo missions to the Moon.

© ESA–R.Shone

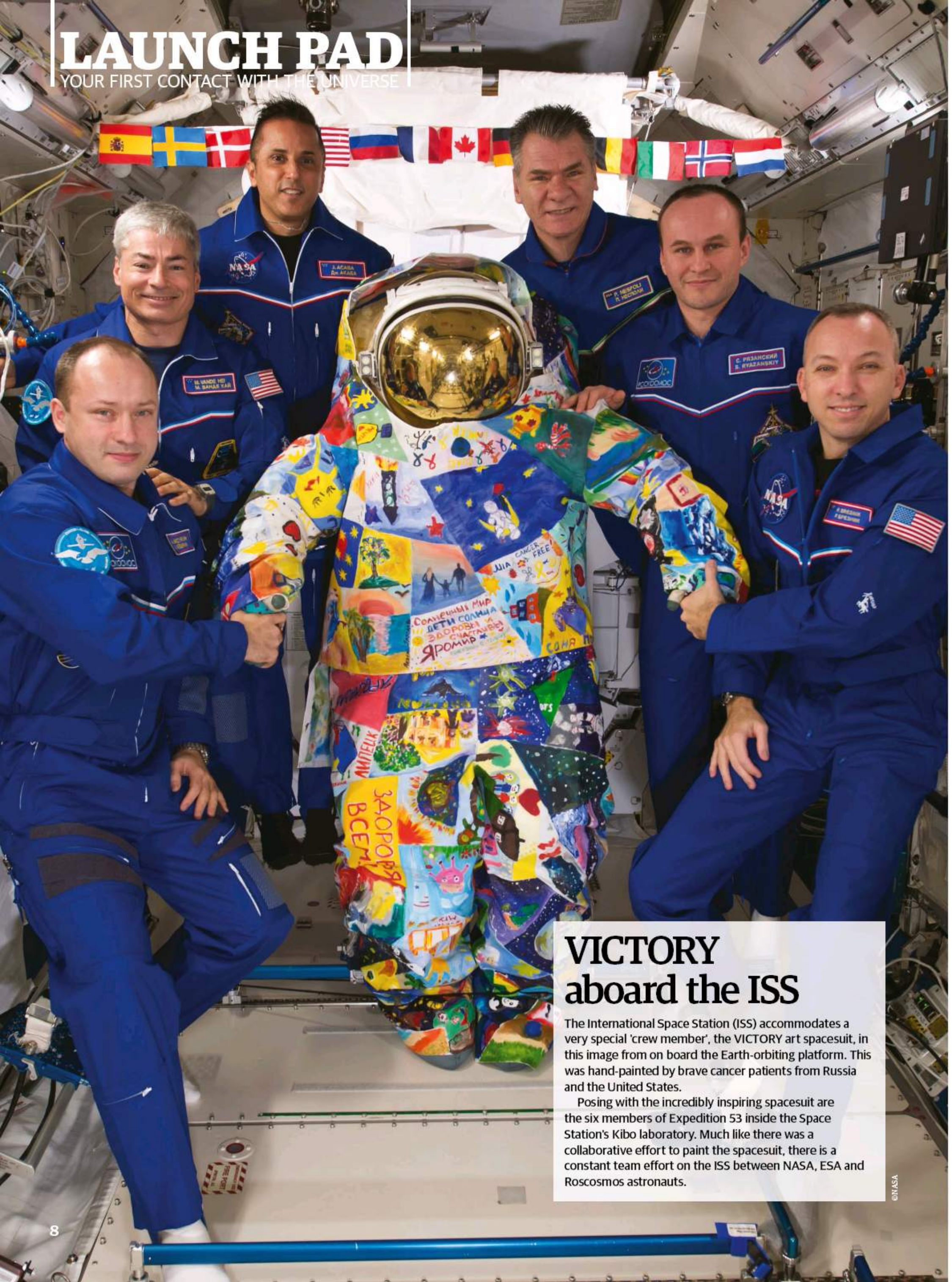


Red supermoon delight

If you are a fond lunar observer, you are in for a treat at the end of the month! Pictured here is the first of three consecutive supermoons on 3 December 2017, illuminating the skies of Washington, United States with a reddish glow.

A supermoon is a full Moon that is at its closest point as it travels around Earth - astronomers dub this distance between our planet and the lunar surface as the perigee, which brings a brighter and more enhanced sight of our Moon.

© NASA/Bill Ingalls

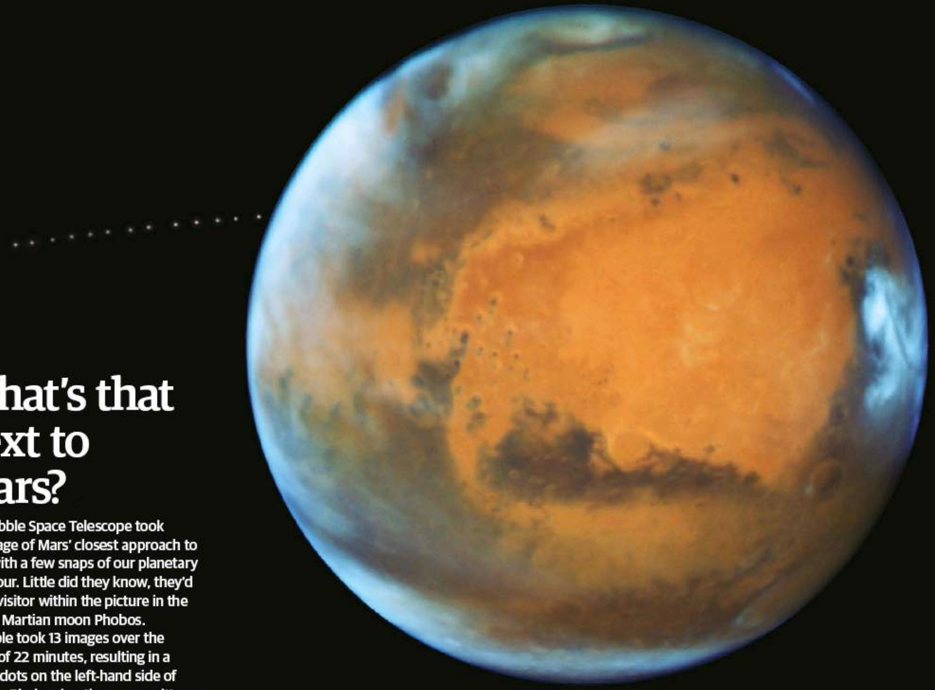


VICTORY aboard the ISS

The International Space Station (ISS) accommodates a very special 'crew member', the VICTORY art spacesuit, in this image from on board the Earth-orbiting platform. This was hand-painted by brave cancer patients from Russia and the United States.

Posing with the incredibly inspiring spacesuit are the six members of Expedition 53 inside the Space Station's Kibo laboratory. Much like there was a collaborative effort to paint the spacesuit, there is a constant team effort on the ISS between NASA, ESA and Roscosmos astronauts.

©NASA



What's that next to Mars?

The Hubble Space Telescope took advantage of Mars' closest approach to Earth with a few snaps of our planetary neighbour. Little did they know, they'd have a visitor within the picture in the form of Martian moon Phobos.

Hubble took 13 images over the course of 22 minutes, resulting in a strip of dots on the left-hand side of Mars. As Phobos is a tiny moon – it's no longer than 27 kilometres (16 miles) – it only appears as a speck as the space telescope tracked it around the planet.

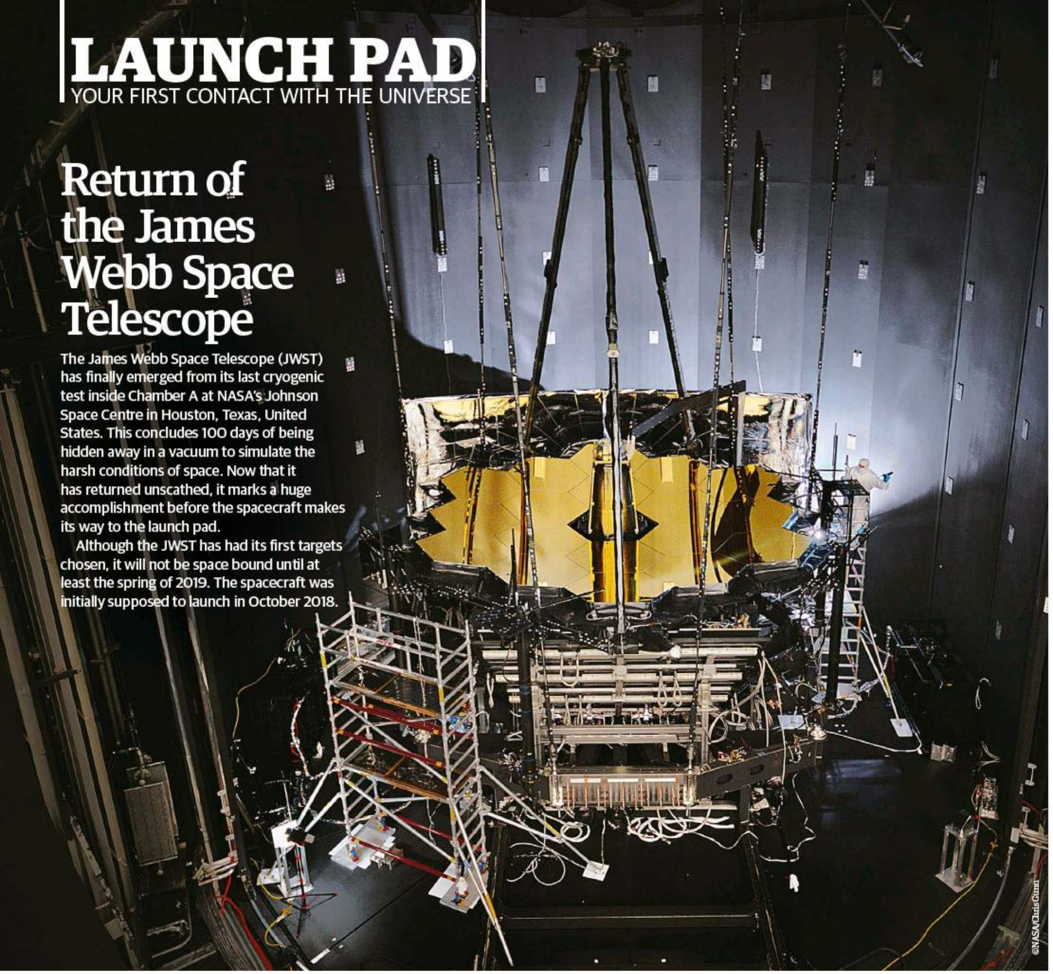
©NASA/ESA

A galaxy that's missing an arm!

There are many things in the world that belong in pairs: some examples include socks, scissors and glasses. Among spiral galaxies, a common feature is a pair of spiral arms, but, after looking at the ESA and NASA's Hubble Space Telescope image of the dwarf galaxy NGC 4625, it's made astronomers beg the question, where is its other spiral arm?

This dwarf galaxy is located 30 million light years away in the constellation of Canes Venatici (The Hunting Dogs), and astronomers suggest that another galaxy's gravitational influence has stolen one of its spiral arms.

©ESA/Hubble & NASA



Return of the James Webb Space Telescope

The James Webb Space Telescope (JWST) has finally emerged from its last cryogenic test inside Chamber A at NASA's Johnson Space Centre in Houston, Texas, United States. This concludes 100 days of being hidden away in a vacuum to simulate the harsh conditions of space. Now that it has returned unscathed, it marks a huge accomplishment before the spacecraft makes its way to the launch pad.

Although the JWST has had its first targets chosen, it will not be space bound until at least the spring of 2019. The spacecraft was initially supposed to launch in October 2018.

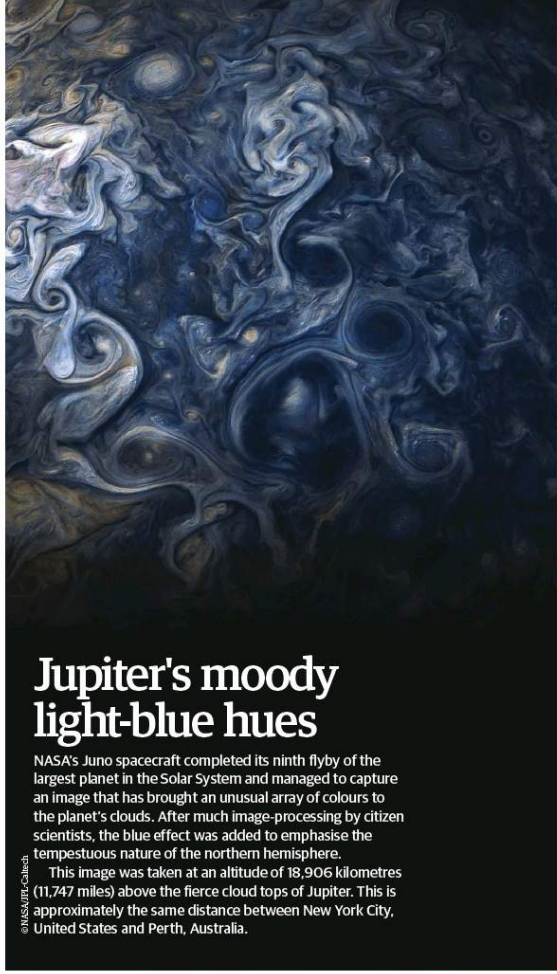
©NASA/Chris Gunn

Sending JPSS-1 to space

© NASA/Kim Shiflett

At the Vandenberg Air Force Base in California, United States, the NAOO-20 (formally known as the Joint Polar Satellite System-1) spacecraft was launched into orbit aboard the United Launch Alliance Delta II rocket.

This satellite is a combined effort between NASA and the National Oceanic and Atmospheric Administration (NAOO), which will provide high-precision accuracy for the United States' weather forecasts. It is the first of a series of four next-generation environmental satellites that accommodate incredibly new and innovative technologies.

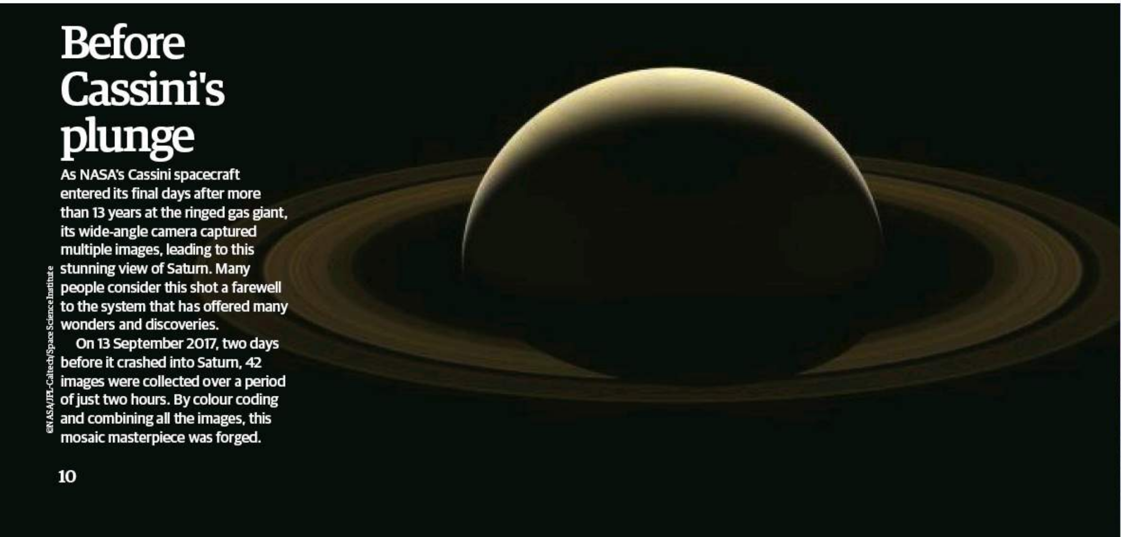


Jupiter's moody light-blue hues

NASA's Juno spacecraft completed its ninth flyby of the largest planet in the Solar System and managed to capture an image that has brought an unusual array of colours to the planet's clouds. After much image-processing by citizen scientists, the blue effect was added to emphasise the tempestuous nature of the northern hemisphere.

This image was taken at an altitude of 18,906 kilometres (11,747 miles) above the fierce cloud tops of Jupiter. This is approximately the same distance between New York City, United States and Perth, Australia.

©NASA/JPL-Caltech



Before Cassini's plunge

As NASA's Cassini spacecraft entered its final days after more than 13 years at the ringed gas giant, its wide-angle camera captured multiple images, leading to this stunning view of Saturn. Many people consider this shot a farewell to the system that has offered many wonders and discoveries.

On 13 September 2017, two days before it crashed into Saturn, 42 images were collected over a period of just two hours. By colour coding and combining all the images, this mosaic masterpiece was forged.

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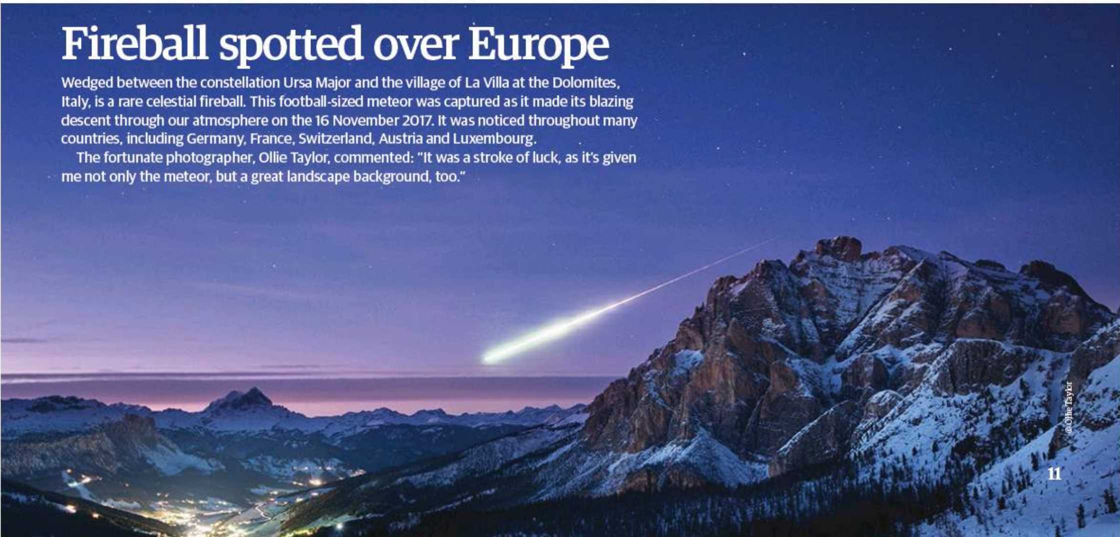


Fireball spotted over Europe

Wedged between the constellation Ursa Major and the village of La Villa at the Dolomites, Italy, is a rare celestial fireball. This football-sized meteor was captured as it made its blazing descent through our atmosphere on the 16 November 2017. It was noticed throughout many countries, including Germany, France, Switzerland, Austria and Luxembourg.

The fortunate photographer, Ollie Taylor, commented: "It was a stroke of luck, as it's given me not only the meteor, but a great landscape background, too."

©Ollie Taylor

Living bacteria from space found on Space Station

Swabs taken from the exterior of the space lab indicate that it doesn't have Earthly origins

Living bacteria found on the exterior of the International Space Station (ISS) could be alien in origin, according to a cosmonaut who has served on board the space lab. Russian Anton Shkaplerov says cotton-swabbed samples collected from the surface of the ISS have been studied on Earth. "It turns out that somehow these swabs reveal bacteria that were absent during the launch of the ISS module," he reveals, adding: "They have come from outer space and settled along the external surface."

Although some scientists have subsequently cast doubt on the claims, the samples were gathered during one of the Russians' regular spacewalks outside the ISS. On this occasion, greater attention was paid to the areas where the station's surface was more obscure and where the accumulation of fuel wastes were discharged during the engines' operation.

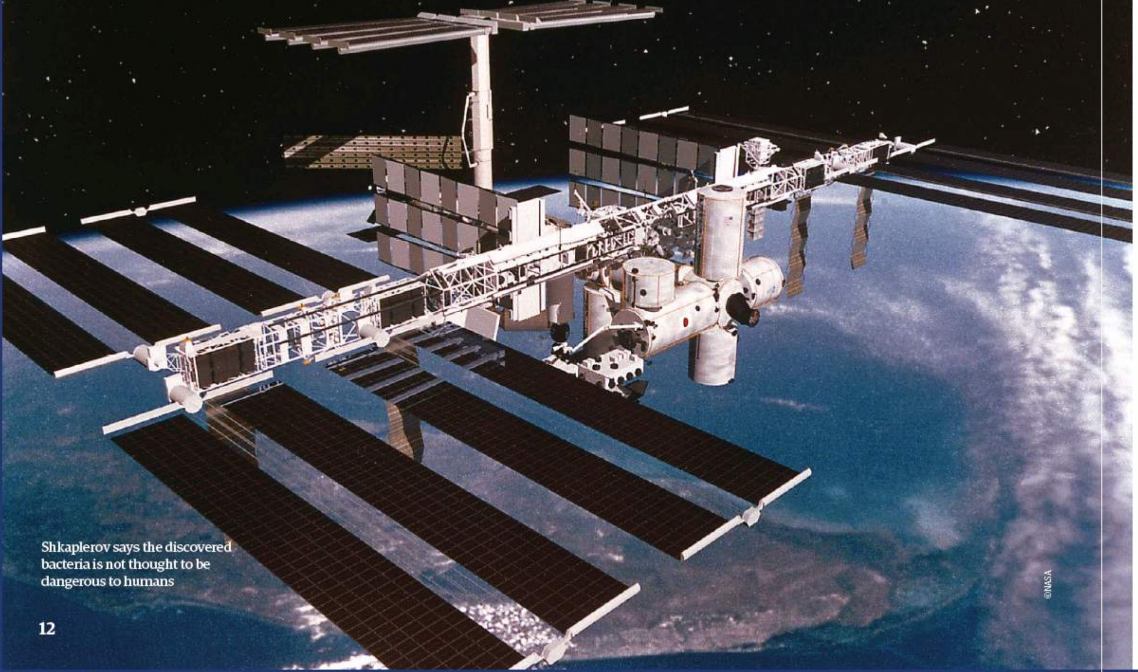
As is routine, they were then sent to scientists on Earth for analysis. But while Shkaplerov goes on to claim in his interview with the Russian state-owned TASS news agency that the bacteria do not pose any danger to humans, he doesn't reveal where the samples are being studied, or by who.

It is this lack of detail about the nature of the experiments, and uncertainly over whether the research has been peer-reviewed, that has led other scientists to tread carefully, mindful that there could be a perfectly 'innocent' explanation for the discovery. Some say it is likely the Space Station's exterior has become contaminated by organisms based on Earth, and that they have merely survived their harsh orbital environment.

TASS has also pointed out that terrestrial bacteria has previously survived on the ISS' exterior, despite being exposed to temperature swings of between -150 to 150 degrees Celsius. Even so, it's an intriguing situation and there is no doubting Shkaplerov's credentials as an accomplished cosmonaut. He has served two stints onboard the ISS, and he is currently leading Russia's crews on a third.

There is a belief that some Earth-originated bacteria may have been lifted from the planet via ionosphere lift, in which rising air currents transport it upwards. Large numbers of astronauts and cosmonauts travelling to the ISS could also have transferred germs and bacteria too. One thing's for sure, it is highly likely that further swabs will be taken and greater analysis will also be needed in order to crack the mystery.

> "They have come from outer space and settled along the [ISS'] external surface"



Shkaplerov says the discovered bacteria is not thought to be dangerous to humans

©NASA

NASA tweaks plans for human space travel

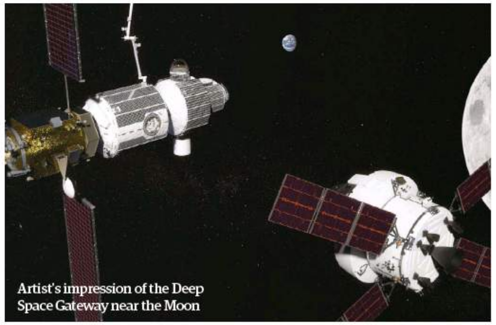
The Deep Space Gateway is seen as being fundamental to the future of manned space exploration

NASA and 14 other international space agencies have laid out plans for exploring the universe over the coming years in a newly released document. The Global Exploration Roadmap, which has been drafted by the International Space Exploration Coordination Group, includes common goals for a habitat between the Earth and the Moon, lunar missions, missions to Mars and an extended presence in low-Earth orbit.

Spread over three phases, it starts with plans for ongoing research and testing on the ISS, but goes on to propose exploring the lunar vicinity in the 2020s before sending exploration missions to orbit Mars in the 2030s. Also discussed are plans for the Deep Space Gateway, which NASA is keen to gather more support for. Set to be constructed in the 2020s, this lunar space station would become a testing ground for astronauts and their equipment.

"We see an orbital platform as playing a vital and synergistic role with anything you do on the surface," says John Guidi, the advanced exploration systems deputy director for NASA. Possibilities include the use of reusable landers that launch from the Deep Space Gateway to asteroids and Mars. "Cislunar orbit is the sweet spot," Guidi adds. "It's close enough to Earth and the Moon, but out of the gravity wells."

Funding for the ISS, which was launched in 1998, is set to carry on until at least 2024, and the space station will continue to be maintained. Meanwhile, Boeing, Lockheed Martin, Orbital ATK, Sierra Nevada Space Systems and Space Systems Loral have been awarded contracts for Deep Space Gateway totalling $2.4 million. They are looking at how they would develop a module capable of powering and propelling it around the Moon.



Artist's impression of the Deep Space Gateway near the Moon

Triton destroyed Neptune's original satellites

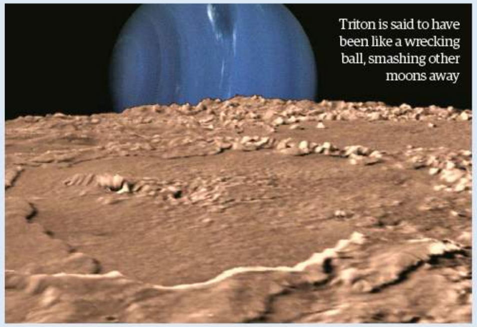
Researchers say the moon was a homewrecker, which crashed into the ice giant's moons and created a new order

Neptune's biggest moon, Triton, may have acted as a wrecking ball in the distant past, smashing away other satellites that were in orbiting the planet. At least that's the theory proposed by intriguing new research, which appears to go some way to explain why Triton has a backward orbit and makes up a whopping 99 per cent of all of the mass orbiting Neptune.

Using a computer simulation, the researchers modelled a family of satellites around Neptune that was similar to those of other gas giants, such as Jupiter. They then introduced Triton and watched as it swallowed some of the satellites, knocked others into Neptune and crashed many out of orbit. The assumption was that Triton was part of a binary system and that it was captured.

The study showed that, over time, the impacts caused Triton to orbit more smoothly around Neptune and fall into line with its gravitational pull. As Robin Canup, of the Southwest Research Institute in Colorado, explains: "It destroyed the well-behaved satellite system that was there before it."

Researchers say that the early moons were too small to destroy Triton, so they succumbed instead. They also say Neptune most likely had a moon system close in total mass to Uranus'. During the collisions, they argue, the smaller moons slowed Triton down, while the outer moons were left relatively unscathed.



Triton is said to have been like a wrecking ball, smashing other moons away

Space News in Brief

CMB scientists awarded major prize

Researchers who worked on NASA's pioneering WMAP space mission which mapped the cosmic microwave background have been awarded the 2018 Breakthrough Prize in Fundamental Physics. Their work dated the age of the universe to about 13.8 billion years, as well as its basic composition and rate of accelerating expansion.

© NASA/JPL

Voyager 1's fired up after almost 40 years

NASA's Voyager 1 has fired up its thrusters for the first time in 37 years. The trajectory correction manoeuvre thrusters on the spacecraft - which was launched just over 40 years ago - were found to be working well.

Musk to send Tesla car to Mars

Elon Musk has laid out plans to launch his Tesla Roadster car into Mars orbit on board SpaceX's Falcon Heavy. He says the car would play David Bowie's *Space Oddity* and would be in deep space for a billion years - assuming it didn't blow up. on ascent.

Arecibo Observatory gets extension

The Arecibo Observatory in Puerto Rico - celebrating its 55th anniversary this year - is set to keep operating. It was at risk of losing funding and was also hit by a Category 4 storm in September, but scientists are hoping for an upgrade.

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Twin planet discovery could solve 'puffy' world mystery

Scientists think they know why some planets are able to grow larger than small stars

The question of how gas giants such as Jupiter came to be so large may have been answered in a new theory put forward by scientists. A team at the University of Hawaii Institute for Astronomy picked up on a hypothesis by Eric Lopez, of NASA's Goddard Space Flight Center, which said orbiting planets are inflated by direct energy input from a host star. They have now discovered that he may on the right lines.

The team, led by Samuel Grunblatt, began by looking at data concerning 'hot Jupiters' - planets which tend to be larger than Jupiter and Saturn yet have similar masses. They studied such hot Jupiters orbiting red giant stars - that is, those in the late stages of their lives - and, while doing so, they came across twin planets similar in mass, size and orbital periods.

Using stellar oscillations, they were able to calculate the radii of the stars and planets, and they found the planets were 30 per cent larger than Jupiter, yet they were only half as massive. They then calculated the efficiency of the planets at absorbing heat from the star and transferring it to their deep interiors.

As a result, the planets were found to need the increased radiation from the red giant star, but the amount of radiation they absorbed was found to be lower than expected. According to a statement by the team, it points to evidence that stellar radiation alone can directly alter the size and density of a planet.

Gas giants are thought to expand as its host star evolves into a red giant

©NASA

Cigar-shaped asteroid first interstellar visitor to Solar System

Astronomers predict that there's likely to be more

An asteroid which was observed to pass by Earth came from outside our Solar System, astronomers have confirmed. 'Oumuamua, which was originally called A2017 U1, was discovered in October - and it's bizarre cigar-shaped appearance has made it even more notable. "This thing is an oddball," says Karen Meech of the University of Hawaii's Institute of Astronomy. It was discovered using the Pan-STARRS 1 survey telescope on Haleakala in Hawaii when it was just 85-times the Earth-Moon distance away. Announced in November, it has since faded from view, but Meech describes it as being a "rapid rotating object, at least the size of a football field, that changed in brightness quite dramatically."

Meech says the change in brightness "hints that 'Oumuamua could be more than 10-times longer than it is wide - something which has never been seen in our own Solar System." But she also says it shares similarities with small objects outside our neighbourhood. "While study of 'Oumuamua's colours shows that this body shares characteristics with both Kuiper Belt objects, organic-rich comets and Trojan asteroids, its orbital path says it comes from far beyond," she adds. Astronomers believe the object travelled for millions of years before arriving at our Solar System and that is has come from the direction of the constellation Lyra. It passed by Mars' orbit on 1 November, travelling at 137,920 kilometres (85,700 miles) per hour. It will reach Jupiter's orbit at some point in 2018. The team now believes such visitors are more common than once thought, and they'll be keeping a firm eye on the night skies for them.

An artist's impression of the cigar-shaped asteroid Oumuamua

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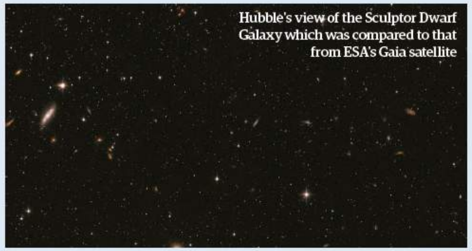

Hubble's view of the Sculptor Dwarf Galaxy which was compared to that from ESA's Gaia satellite

Record-breaking star measurement puts dark matter on trial

Data is helping astronomers to better understand the nature of the mysterious substance

The 3D motions of individual stars in a nearby galaxy have been directly measured by combining two sets of data - shedding new light on the distribution of invisible dark matter. A team of astronomers from two Dutch astronomy institutes took data from the Hubble Space Telescope and the Gaia space observatory 12-years apart. It allowed them to measure the stars 300,000-light-years away in the Sculptor Dwarf Galaxy. They were also able to achieve a level of accuracy never before seen for a galaxy outside the Milky Way.

Since the Sculptor Dwarf Galaxy is thought to be dominated by dark matter, the astronomers saw it as an ideal target for study. "One of the best ways to infer the presence of dark matter is to examine how objects move within it," says Amina Helmi, of Kapteyn Astronomical Institute. "In the case of dwarf spheroidals, these objects are stars." The results show that the stars here move preferentially on elongated radial orbits which is a strong indication that the density of dark matter increases towards the core of the galaxy.

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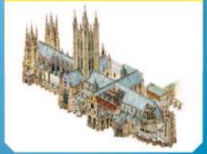

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EXCLUSIVE: ELON MUSK AND RICHARD BRANSON REVEAL

THEIR FIGHT FOR MARS

It's the battle of the billionaires: two of the private space industry's most exciting companies - SpaceX and Virgin Galactic - go head-to-head and they're proving to be fiercely competitive

FREE MARS PULL-OUT POSTER PAGE 50

© NASA; ESA; Virgin Plc Ltd; SpaceX; Adrian Mann

There are many similarities between Elon Musk and Richard Branson. For a start, both are serial entrepreneurs: Branson runs the British multinational Virgin Group which has interests in health, entertainment, publishing, travel and motorsport, while Musk is the co-founder of PayPal, the chairman of SolarCity and the chief executive of Tesla.

As a consequence, they are both billionaires, and very well-respected ones at that. Musk may only be 46-years old but, as a brilliant engineer with one of the greatest minds of a generation, he is often favourably compared to the equally genius (yet fictitious) Tony Stark of *Iron Man* fame. Branson is, at 67, 21 years his senior, yet he has proved to be equally worthy superhero in his endeavours. His penchant for balloon travel has seen him get into a few scrapes, but his frequent world-record attempts have seen him become the first man to fly over Mount Everest. Like Musk, however, Branson's current venture is set to take him even further still.

Having delivered cargo to the ISS, the booster lands successfully on the drone ship, Of Course I Still Love You

Branson and Musk are obsessed with space, and they are putting sizeable wedges of cash towards their respective ventures and ambitions. Branson has set up Virgin Galactic with the aim of encouraging passengers to stump up $250,000 for the undoubted pleasure of coasting towards the edge of space in its VSS Unity spacecraft. Musk founded SpaceX, which ultimately plans to populate the Red Planet, allowing anyone who can muster $200,000 the opportunity to embark on the potential one-way trip of a lifetime.

Yet it is here where the two men differ, and where their personal space race assumes a separate path - Musk's sights are set on the Red Planet, while Branson wants it all. "Elon is absolutely fixated on going to Mars, and I think it's his life mission," Branson says. "I am more interested in how we can use space to benefit the Earth, because the Earth is, in my opinion, extremely beautiful, and needs to be protected."

Like Musk, Branson has expressed interest in colonising the surface of the Red Planet - but he's willing to share with the CEO of SpaceX. "Mars is a big place. When we colonise Mars, Musk can have the west end, and we're gonna have the east end," he laughs. "There's room for us both." Speaking on resources for future settlers on Mars, Branson states: "I think there's plenty of frozen water, and those things, so we'll share the water." Musk, for his part, has indeed long argued that we must colonise the Red Planet. Should we seek to stay on Earth forever, he believes, "there will be some eventual extinction event." A case of do or die, then.

Of course, the end of our own planet is unlikely to happen any time soon, which is perhaps why Virgin Galactic is, for the time being at least, more concerned with letting would-be passengers have a bit of fun (as opposed to SpaceX's aim of saving the human race). Branson hopes his company - which was founded in 2004 - could send its first astronauts into low-Earth orbit by early 2018, and that tourists will be rocketing skywards by the end of that year, realising a dream which has so far been reserved of those hand-picked for their skills by the world's space agencies.

Should Branson's estimates come true, then it means the 700 or so people signed up for the ride so far (reportedly including the actors Tom Hanks and Angelina Jolie) will enjoy unbuckling and experiencing several minutes of weightlessness in space sooner rather than later. They will be able to see Earth from a far greater height than any aeroplane could take them and, given that space has only been explored by 560 or so people so far, it would be something of a breakthrough. As Virgin Galactic points out on its website, it is opening space to the rest of us (providing we have enough money). Musk is looking to do the same but on different terms: with Virgin you get to come back; with SpaceX, the journey to Mars is likely to be one way.

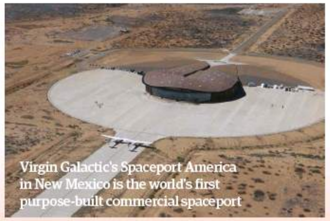
> "Elon is absolutely fixated on going to Mars, and I think it's his life mission"
>
> **Richard Branson**

Professor Stephen Hawking is certainly excited about these developments. Branson has offered the 75-year-old physicist a place aboard the Virgin Galactic spaceship, giving him the chance to fulfill his "ultimate ambition" of flying. Hawking, who chose the name Unity and whose eye is used as the model for the logo on the side of spacecraft, reveals that he accepted the offer. "Since that day, I have never changed my mind," he tells **All About Space**.

Hawking, who also shares the same views as Musk, has also claimed that we must look at colonising a new planet in the next 100 years, or suffer fatal future consequences. That would be music to Musk's ears as he seeks a band of space-faring pioneers determined to make the human race multi-planetary. "However, we will not establish self-sustaining colonies in space for at least the next hundred years, so we have to be very careful in this period," warns Hawking.

Musk wants to ferry people in a pressurised section of what he used to call the Mars Colonial Transporter but is now referred to as the Big Falcon Rocket, or BFR for short. Eventually, he hopes the journey time to the Red Planet will be just 30 days, but the idea is that the spacecraft would carry tons of cargo and building material and enable the colonisers to produce the necessary infrastructure and home comforts. "We'll have 450 tons of luggage and all of the unpressurised cargo to build everything from iron foundries, pizza joints, you name it," he says.

SpaceX is working with NASA, having docked their Dragon spacecraft at the International Space Station


Virgin Galactic's Spaceport America in New Mexico is the world's first purpose-built commercial spaceport

VSS Unity, built by The Spaceship Company, made its first free flight in December 2016, piloted by Mark Stucky and Dave Mackay

© SpaceX; Virgin Group Ltd

Elon Musk VS Richard Branson

As two of the most successful entrepreneurs in the world, they have the impressive CVs to match

Elon Musk

Net Worth: $20.2 Billion

"Failure is an option here. If things are not failing, you are not innovating enough"

© Gregg DeGuire / Getty Images

1983 Early talent
Having taken an interest in computer programming in his earlier years, at the age of 12, Musk used his new-found skills to create a game called *Blastar*, which he sold to a magazine for $500.

1992-1995 Graduated from university
Musk began his studies at Queen's University in Kingston, Ontario, Canada where he spent two years before moving to the University of Pennsylvania. He has two degrees: one in physics and one in economics.

2002-Present Founded SpaceX
Musk founded Space Exploration Technologies in a bid to slash the costs of launching spacecraft. Known as SpaceX, it works with NASA and aims to make travel to Mars affordable.

1995-2002 Headed up PayPal
After founding Zip2, which licensed city guide software to newspapers, Musk set up the online banking company X.com. Following a merger it became PayPal, and Musk emerged as CEO.

2004-Present Involvement with Tesla Motors
Having invested heavily in Tesla, Musk became chairman of the board. Today he is CEO and Product Architect, presiding over what promises to be an electric car revolution.

2016-Present Creates The Boring Company
Believing congestion is best relieved by sending traffic underground, The Boring Company's inexpensive tunnels tie in with Musk's concept of a hyperloop - transporting passengers in pressurised capsules in tubes.

Richard Branson

Net Worth: $5.1 Billion

1966 Set up a magazine
Although Branson struggled with school and dropped out at 16, his entrepreneurial flair was evident early on. In 1968, he launched *Student* magazine making money by selling advertisements.

1970-Present Created Virgin
After selling music by mail order, Branson opened his first record shop on Oxford Street in London, calling it Virgin because he was a beginner at business. A record label followed.

1986 Smashed a world record
Branson crossed the Atlantic in a powerboat for more than three days, but completed the journey two hours faster than the previous record-holder. He has made many other record attempts since.

1984-Present Launched Virgin Atlantic
Branson became a thorn in British Airways' side when he launched a rival airline, Virgin Atlantic, quickly establishing itself by the decade's end.

1993 Received an honorary degree
Having recognised his growing accomplishments, Loughborough University made him an honorary Doctor of Technology. In 2000, he was knighted by Charles, Prince of Wales for his 'services to entrepreneurship.'

2004-Present Launched Virgin Galactic
Not content with launching Virgin Trains in 1997, Branson went a step further and created Virgin Galactic, which aims to open up space travel to anyone able to stump up the cash.

"You don't learn to walk by following rules. You learn by doing and by falling over"

© Ray Tamara / Getty Images

The Dragon is a reusable spacecraft developed by SpaceX. It's launched by the Falcon 9 rocket

Keen on conquering space, Branson hasn't let returning to the lunar surface escape his notice. "Why not have a hotel in space?" he asks. "How fantastic would it be to go and spend a week in a space hotel?"

With the two billionaires keeping their eyes locked on space, **All About Space** asked Musk whether he was thinking bigger than Branson. "He did name his firm Virgin Galactic. That's pretty big," Musk replied. "It's a bit like your name is Giant and you're actually quite small." He then added: "Technology is not really his whack you know."

Branson counteracted this claim and said he hoped to prove Musk wrong. He added that his own strength was surrounding himself with brilliant people (and indeed, in 2010, Virgin Galactic secured the services of George Whitesides, NASA's former chief of staff, as its chief executive). He also claimed his technology would eventually be able to transport passengers across the Earth in spaceships, and put thousands of small satellites into space: two of the ways Branson says his company's missions will benefit people intent on remaining on this planet. Perhaps more interesting is the notion discussed on Virgin Galactic's website that "space is not only important for the future of transportation, commerce and science; it's also important for the future of imagination." This is where a line may be drawn between the aims of Virgin Galactic and that of SpaceX in this very modern space race.

Whereas Musk wants to save humankind by physically transporting as many as a million people to Mars on a total of 10,000 trips over the course of 40 and 100 years (the capacity of the spacecraft is 100), Branson wants to do the same by altering mental attitudes. He talks of the Overview Effect, felt by astronauts when they go into space: "Having left the Earth and seen it from thousands of miles away, they gain new perspective on their home planet, and see how tiny the differences are and how great the shared bonds," he writes. "They return with a profound desire to change the world for the better."

Musk appears to think differently. He feels that humans on Earth will only strive to resolve the problems they have created when they realise the mess they're in is real. In that sense, he isn't overly concerned about shaping minds right now, believing it will happen naturally and in due course. "The sustainable energy future, I think, is largely inevitable, but being a space-faring civilisation is definitely not inevitable," he says. Attempting to save humans, wherever they may end up, is more of a priority than purely trying to make Earth alone better, it seems.

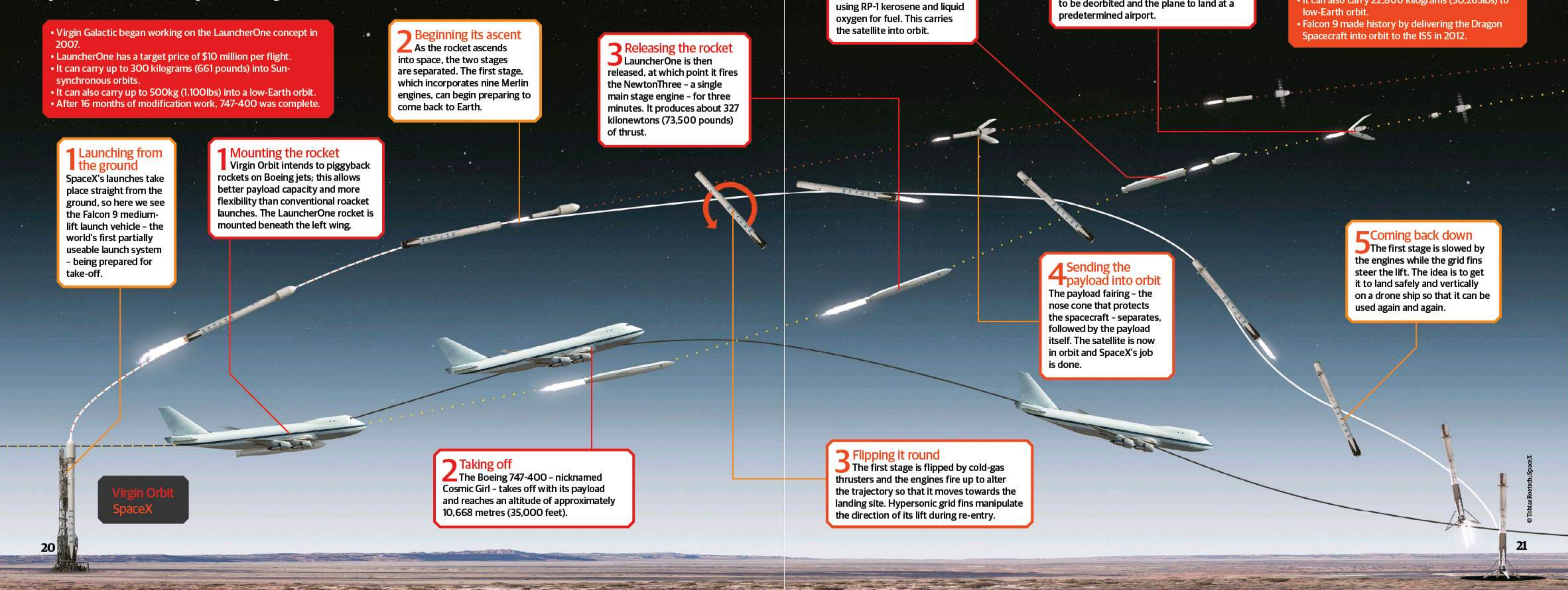
Even so, both Musk and Branson are interested in bettering lives through faster transport, which is why they are also locked in a side-battle over hyperloop technology. The brainchild of Musk, hyperloop involves whizzing passengers from A to B on Earth in pressurised capsules. However, while the chief of SpaceX's The Boring Company seeks to build hyperloop tunnels underground, Hyperloop One, in which Branson has invested, prefers tunnels to be overground. Different approaches and different mindsets appear to be at play at every step.

Given their interests overlap, the main question is why they haven't sought to work together? That may go back to 2015, when Branson teamed up with Alphabet CEO Larry Page to develop a space-based

> "He did name his firm Virgin Galactic. It's a bit like your name is Giant and you're actually quite small" **Elon Musk**

Virgin Orbit vs SpaceX

Branson and Musk also want to send private satellites into space on behalf of companies and governments



- Virgin Galactic began working on the LauncherOne concept in 2007.
- LauncherOne has a target price of $10 million per flight.
- It can carry up to 300 kilograms (661 pounds) into Sun-synchronous orbits.
- It can also carry up to 500kg (1,100lbs) into a low-Earth orbit.
- After 16 months of modification work, 747-400 was complete.

1 Launching from the ground
SpaceX's launches take place straight from the ground, so here we see the Falcon 9 medium-lift launch vehicle – the world's first partially useable launch system – being prepared for take-off.

1 Mounting the rocket
Virgin Orbit intends to piggyback rockets on Boeing jets; this allows better payload capacity and more flexibility than conventional roacket launches. The LauncherOne rocket is mounted beneath the left wing.

2 Beginning its ascent
As the rocket ascends into space, the two stages are separated. The first stage, which incorporates nine Merlin engines, can begin preparing to come back to Earth.

2 Taking off
The Boeing 747-400 – nicknamed Cosmic Girl – takes off with its payload and reaches an altitude of approximately 10,668 metres (35,000 feet).

3 Releasing the rocket
LauncherOne is then released, at which point it fires the NewtonThree – a single main stage engine – for three minutes. It produces about 327 kilonewtons (73,500 pounds) of thrust.

3 Flipping it round
The first stage is flipped by cold-gas thrusters and the engines fire up to alter the trajectory so that it moves towards the landing site. Hypersonic grid fins manipulate the direction of its lift during re-entry.

4 Shipping the satellite
Now a single upper-stage engine – the NewtonFour – kicks in. It has 22 kilonewtons (5,000 pounds) of thrust, using RP-1 kerosene and liquid oxygen for fuel. This carries the satellite into orbit.

4 Sending the payload into orbit
The payload fairing – the nose cone that protects the spacecraft – separates, followed by the payload itself. The satellite is now in orbit and SpaceX's job is done.

5 Releasing the payload
After executing multiple burns for around six minutes, LauncherOne deploys the satellite into its orbit. Its job is now done, allowing the two LauncherOne stages to be deorbited and the plane to land at a predetermined airport.

5 Coming back down
The first stage is slowed by the engines while the grid fins steer the lift. The idea is to get it to land safely and vertically on a drone ship so that it can be used again and again.

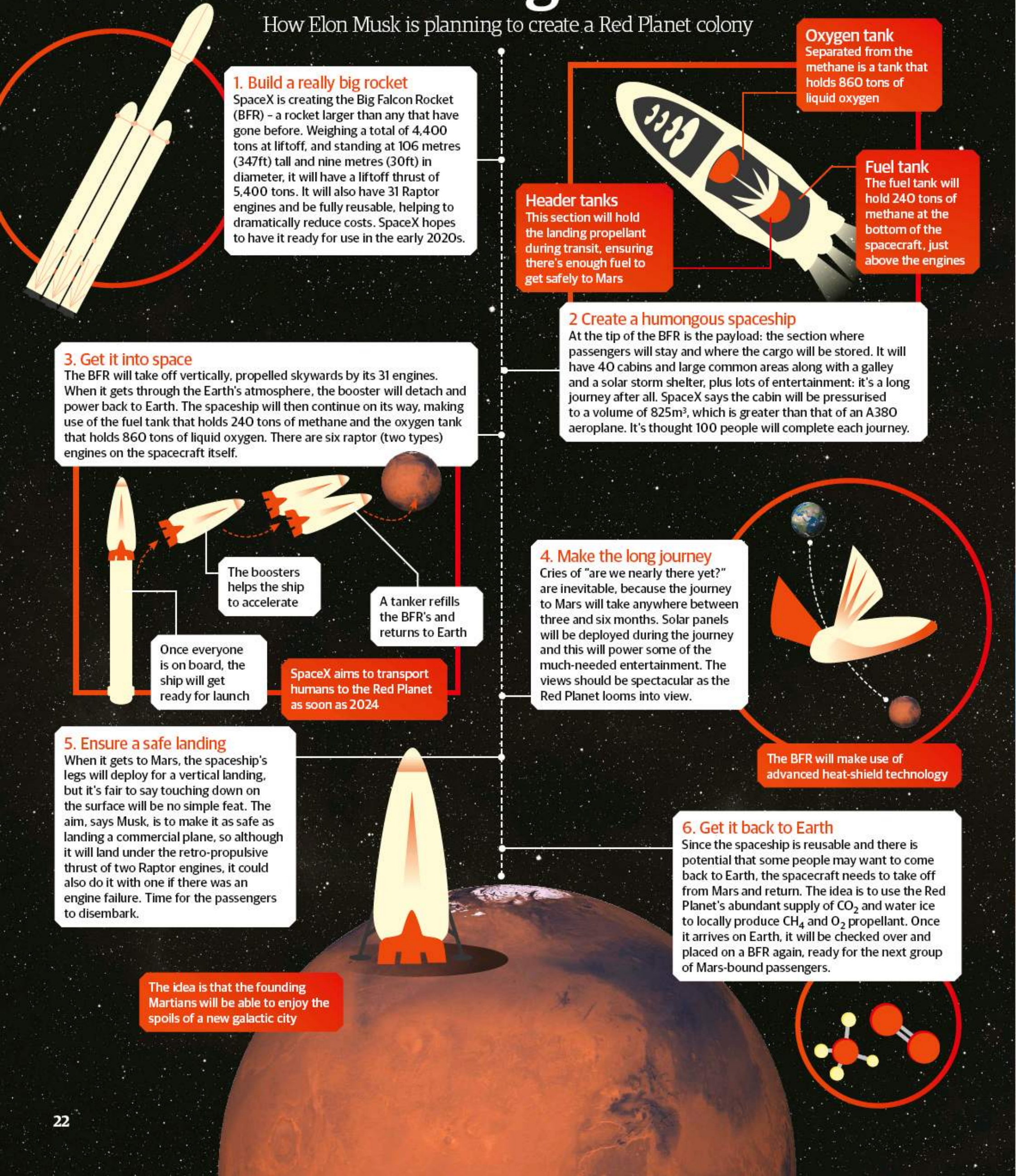
- SpaceX began working on Falcon 9 in 2006.
- It can launch a payload for a minimum of $62m, according to its website.
- Falcon 9 is capable of carrying 8,300 kilograms (18,300lbs) into geostationary transfer orbit.
- It can also carry 22,800 kilograms (50,265lbs) to low-Earth orbit.
- Falcon 9 made history by delivering the Dragon Spacecraft into orbit to the ISS in 2012.

Virgin Orbit
SpaceX

© Tobias Roetsch; SpaceX

"Mars belongs to Elon"

How Elon Musk is planning to create a Red Planet colony



1. Build a really big rocket
SpaceX is creating the Big Falcon Rocket (BFR) – a rocket larger than any that have gone before. Weighing a total of 4,400 tons at liftoff, and standing at 106 metres (347ft) tall and nine metres (30ft) in diameter, it will have a liftoff thrust of 5,400 tons. It will also have 31 Raptor engines and be fully reusable, helping to dramatically reduce costs. SpaceX hopes to have it ready for use in the early 2020s.

Oxygen tank
Separated from the methane is a tank that holds 860 tons of liquid oxygen

Fuel tank
The fuel tank will hold 240 tons of methane at the bottom of the spacecraft, just above the engines

Header tanks
This section will hold the landing propellant during transit, ensuring there's enough fuel to get safely to Mars

2 Create a humongous spaceship
At the tip of the BFR is the payload: the section where passengers will stay and where the cargo will be stored. It will have 40 cabins and large common areas along with a galley and a solar storm shelter, plus lots of entertainment: it's a long journey after all. SpaceX says the cabin will be pressurised to a volume of $825m^3$, which is greater than that of an A380 aeroplane. It's thought 100 people will complete each journey.

3. Get it into space
The BFR will take off vertically, propelled skywards by its 31 engines. When it gets through the Earth's atmosphere, the booster will detach and power back to Earth. The spaceship will then continue on its way, making use of the fuel tank that holds 240 tons of methane and the oxygen tank that holds 860 tons of liquid oxygen. There are six raptor (two types) engines on the spacecraft itself.

The boosters helps the ship to accelerate

A tanker refills the BFR's and returns to Earth

Once everyone is on board, the ship will get ready for launch

SpaceX aims to transport humans to the Red Planet as soon as 2024

4. Make the long journey
Cries of "are we nearly there yet?" are inevitable, because the journey to Mars will take anywhere between three and six months. Solar panels will be deployed during the journey and this will power some of the much-needed entertainment. The views should be spectacular as the Red Planet looms into view.

The BFR will make use of advanced heat-shield technology

5. Ensure a safe landing
When it gets to Mars, the spaceship's legs will deploy for a vertical landing, but it's fair to say touching down on the surface will be no simple feat. The aim, says Musk, is to make it as safe as landing a commercial plane, so although it will land under the retro-propulsive thrust of two Raptor engines, it could also do it with one if there was an engine failure. Time for the passengers to disembark.

6. Get it back to Earth
Since the spaceship is reusable and there is potential that some people may want to come back to Earth, the spacecraft needs to take off from Mars and return. The idea is to use the Red Planet's abundant supply of CO_2 and water ice to locally produce CH_4 and O_2 propellant. Once it arrives on Earth, it will be checked over and placed on a BFR again, ready for the next group of Mars-bound passengers.

The idea is that the founding Martians will be able to enjoy the spoils of a new galactic city

internet that would use inexpensive, low-power satellites for launch by Virgin Galactic.

It appears Branson wanted Musk on board, but "was saddened that Elon didn't consider working with Larry and me."

Instead, SpaceX and Virgin Galactic are charting their own separate paths, and they are both proving to be successful. In October 2017, Virgin Galactic was given a boost thanks to $1 billion in funding from Saudi Arabia, authorised by its new Crown Prince Mohammed bin Salman. "This will enable us to develop the next generation of satellite launches and accelerate our programme for point-to-point supersonic space travel," Branson says. This is, in some sense, another sub-race, because SpaceX is also hoping its rockets will enable point-to-point Earth travel too. Musk has suggested future passengers could wing their way from New York to Shanghai in as little as 39 minutes at over 18,000 kilometres-per-hour (11,372 miles-per-hour).

Branson is also looking to go toe-to-toe with SpaceX in bagging commercial and government contracts. He is doing so with a new space-centred company called Vox Space, based in southern California. It's aim, according to its website, is to "provide the national security community of the USA and allied nations with the ability to launch services for small satellites bound for low-Earth orbit". Another spin off, Virgin Orbit, will also launch services for small satellites, but those government contracts are a lucrative business. SpaceX offers rockets capable of carrying 22,680-kilograms (50,000 pounds) to low-Earth orbit, compated to the 181-kilograms (400-pound) capacity of Vox. It is also designing a spacecraft for NASA.

While Virgin Galactic and SpaceX are not competing with each other to be the first to Mars, they are going head-to-head in other areas. So, while, SpaceX isn't planning on launching its first mission to Mars before 2022 (a timescale even Musk readily admits is "aspirational"), their other plans should come to fruition sooner. Branson is set to win the personal space race, however, since he is very much on course to be the first of the pair to journey into space.

He is certainly keeping himself fit and active so that he can make the journey, even though he admits that the Virgin Galactic project has been one of his greatest challenges. It has already claimed the life of test pilot Michael Alsbury when the first version of the SpaceShipTwo disintegrated over the Mojave Desert in 2014. Virgin Galactic has since received its operating license from the US Federal Aviation Authority, and Branson is also taking part in centrifuge training, which involves being spun to a high speed in order to simulate the feeling of gravity. His body is prepared for the likely strains of space travel.

Musk, on the other hand, is far less likely to be on his spacecraft to Mars in the early stages, although he does want to go eventually. "I'd have to have a really good succession plan [for SpaceX], because the likelihood of death is very high," he explains. He is understandably worried about not seeing his children grow up and he frets that investors may decide, in his absence, not to continue with the Mars plan. But he has said that he wants to die on Mars: "I can't think of anything more exciting than going out there among the stars," he smiles.

One thing's for sure, though, these are fascinating times for both Musk and Branson, and it's heartening to see that the pair are so passionate about space and it's exploration. The levels of investment in their respective endeavours truly brings them together, and there's no suggestion that a bit of healthy competition is a bad thing. With so many clever scientists and engineers working on the various projects, and two driven bosses, we will inevitable reach new heights. The future is indeed looking bright.

> "I can't think of anything more exciting than going out there among the stars"
>
> **Elon Musk**

Hyperloop technology was originally an idea coined by Musk, with Branson investing in the American company Hyperloop One in 2017

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Brian Cox, Bill Nye, Michio Kaku & more on...

THE NEXT BIG BREAKTHROUGHS

With our quest to understand the universe excelling in every frontier, **All About Space** asked some of the world's most renowned scientists what they think the next huge discovery could be

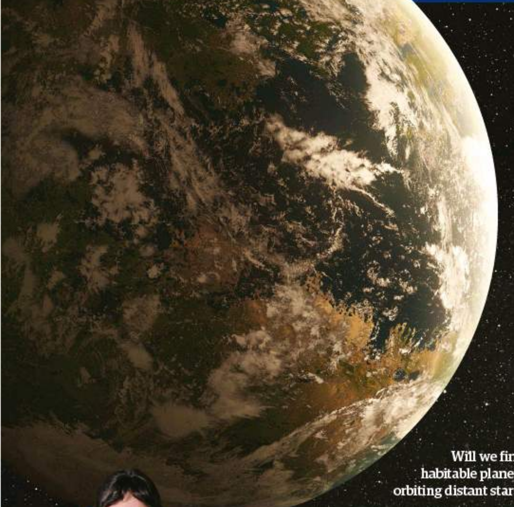
Written by Lee Cavendish

Throughout the years, scientific and technological advances have ensured that there's always another surprise waiting for us around the corner. So who knows what the next big scientific discovery is going to be?

The short answer is, no one knows. However, **All About Space** has picked the brains of some of the world's smartest minds to hazard a guess for us. These scientists discuss possibilities ranging from what technologies could arise – perhaps ushering in the dawn of augmented reality – to finding out what fuels the expansion of the universe, and even the future of human space exploration.

As a human race, we have always strived to further our understanding of the unknown. From this pure determination, new discoveries have also arisen as a consequence. Some have even been by complete accident – take the discovery of penicillin for example. Alexander Fleming only came across this powerful, world-changing antibiotic because he somehow introduced a spore into a petri dish. This is why scientists can't put a definitive answer to the question: what is the next scientific discovery?

In recent years, the advances in science and technology have led to some extremely exciting discoveries, such as the detection of gravitational waves last year. By continuing on this projection of scientific brilliance, these esteemed scientists have provided a comprehensive selection of tantalising possibilities that we could see within our lifetimes.



Will we find habitable planets orbiting distant stars?

© NASA/Tobias Roetsch

Dr Jennifer Wiseman

Jennifer Wiseman is the senior project scientist for the esteemed and extremely successful Hubble Space Telescope. This telescope has supplied us with a constant stream of amazing images and valuable data since its mirror correction in 1993, and still continues to do so.

Detailed information about the surfaces of planets outside our Solar System

"I believe that very exciting results in astronomy over the next decade and beyond will be enabled through complementary observations from multiple, diverse telescopes and facilities. We will have almost unimaginable capabilities available given the simultaneous operations of several flagship space telescopes and giant ground-based facilities, together being sensitive to the full electromagnetic spectrum at high resolution, as well as to cosmic rays, neutrinos and even gravitational waves.

"The power of the 'suite' of diverse observatories was demonstrated dramatically with the recent detection of gravitational waves, and a broad range of associated electromagnetic radiation spawned from a merger of neutron stars in a galaxy outside our own. We can expect many more such multi-faceted detections of major mergers in the next decade, thanks to the suite of available observatories we will have.

"Another hot area for the next decade will be much closer to home: exoplanets! I believe the next decade will offer an outrageous amount of new information about the character of planets outside our Solar System, thanks again to the multiple complementary observatories that will be available in space and on the ground. Facilities like the Transiting Exoplanet Survey Satellite (TESS) will discover potentially thousands of previously unknown exoplanetary systems, and ground based telescopes, as well as flagship space observatories including Hubble and James Webb, will analyse atmospheric compositions, looking for more potentially habitable worlds by correlating spectra across the bandwidths of these diverse observatories."

We'll be living on Mars and asteroids

"A century or two from now, there may be small groups of pioneers living independently from the Earth – on Mars, or on asteroids. Whatever ethical constraints we impose here on the ground, we should surely wish these adventurers good luck in genetically modifying their progeny to adapt to alien environments. That might be the first step towards divergence into a new species.

"Space travel remains challenging so long as we depend on chemical fuels. Nuclear power could be transformative by allowing much higher in-course speeds; it would cut the transit time to Mars or the asteroids and limit exposure to radiation. Incidentally, it could transform manned spaceflight in the Solar System from a high-precision to an unskilled operation.

"Driving a car would be very difficult if you had to program the journey in advance, as it couldn't make any mid-course steering corrections. But if you had plenty of fuel in your rocket, you could make changes, [such as] accelerate or decelerate and it's even easier than most travel, and you can always see your destination. It will be an absolute doddle to go through the Solar System – if you had enough fuel – and this will happen one day."

Humanity could become an interplantetary species in the next few centuries

Lord Martin Rees

Lord Martin Rees is a leading figure for astronomy and astrophysics in the UK. During his career, he has received multiple awards, fellowships and visiting professorships. His work in astronomy has led to his current role of Astronomer Royal and a former president of the Royal Society.

Discovering what dark matter actually is

"Predicting the future is almost impossible, and discoveries by their nature are almost impossible to predict. So, predicting what discoveries are likely to happen must be taken with a grain of salt.

"First let me comment on what I hope will be discovered and I will stick to experimenting, as theoretical advances are maybe even harder to predict. Experimentally, my biggest hope is that we will discover what 'dark matter' is. This is perhaps the biggest outstanding problem in astrophysics, and appears to have an answer in particle physics. There are many searches planned or underway, including accelerator experiments as well as direct searches for dark matter. Finding dark matter could simultaneously solve perhaps the biggest issue in astrophysics, while finally giving us the long sought answer to what is beyond the standard model of particle physics. Is its discovery likely? I kind of doubt it.

"What do I think will be the most likely discoveries in the next decade? I generally think the best guide is where the biggest technical advances will be occurring, and the one that stands out for me is the Large Synoptic Survey Telescope (LSST), which is nearing completion of construction and will be fully operational within about five years. This magnificent instrument will take nearly 1,000 images each night with a 3.2-billion-pixel camera, covering the visible sky every few days. It will detect minute changes of position or brightness of objects millions of times fainter than our eyes. I believe an era of major discovery is inevitable!"

Prof. Barry Barish

Barry Barish is an American experimental physicist, who was jointly awarded the 2017 Nobel Prize in Physics for his role in the detection of gravitational waves.

He is currently a Linde professor of Physics, emeritus at the prestigious California Institute of Technology (Caltech), Pasadena, California.

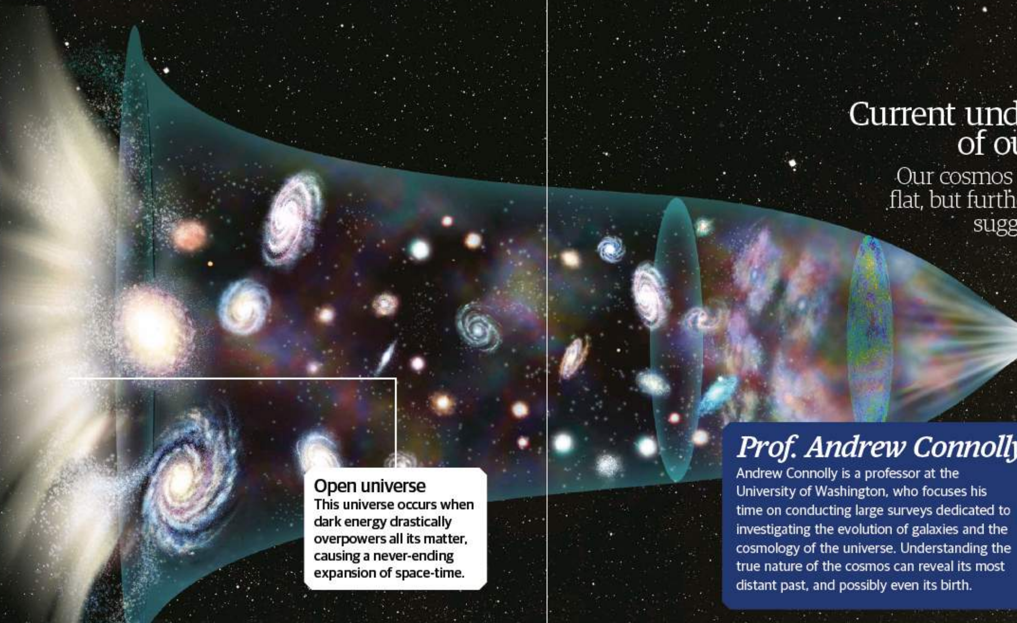
We could discover what happened before the Big Bang

"The more data we get, the more we can look at things like the oldest light in the universe, which is something called the Cosmic Microwave Background (CMB) – the afterglow of the Big Bang, if you like – that we see all over the sky. We've been taking photographs and measurements of that [for decades], and they all seem to confirm this idea, this theory, that before the universe was hot and dense – before the thing we call the Big Bang – there was some other time when it was doing something else. So there are big questions about how long it was doing that other thing for.

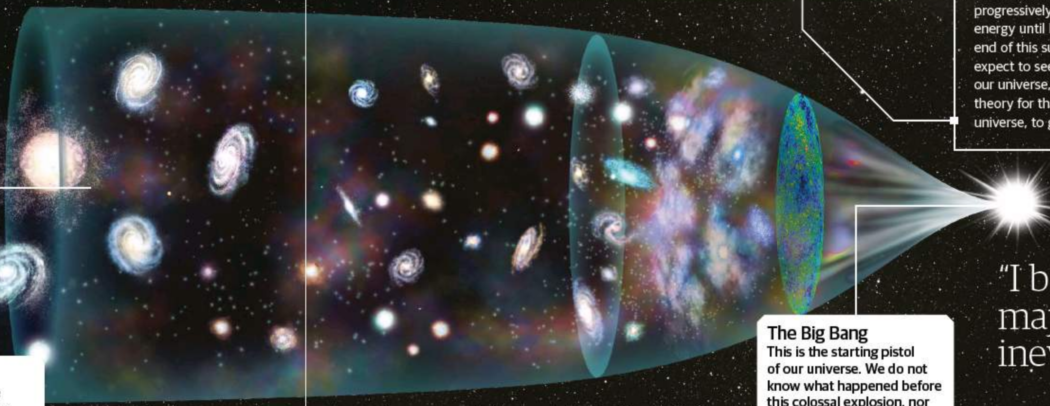
"This idea that we might have a theory that addresses what happened before the Big Bang, that to me is something. It's culturally significant, that theory. I think because it's quite new and quite difficult, it hasn't quite seeped into our understanding."

Prof. Brian Cox

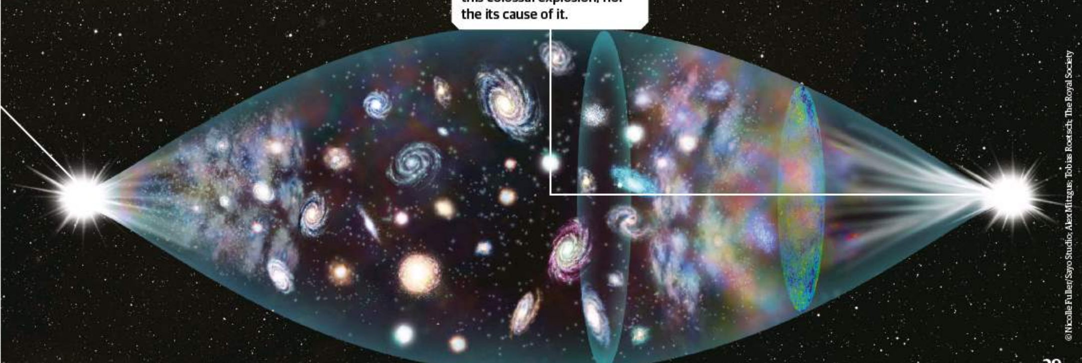
Brian Cox is an English physicist, and his work in communicating the subject has made him a very popular figure. He has presented many BBC shows, including *Stargazing Live* and the *Wonders of the Universe* series. In 2010, the Queen awarded him with an OBE for his services to science.



Open universe
This universe occurs when dark energy drastically overpowers all its matter, causing a never-ending expansion of space-time.



Flat universe
After the initial explosion of the Big Bang, the rate of expansion of the cosmos is increasing. Its ultimate fate is the same as that of an open universe.



Closed universe
This occurs when the matter of the universe overpowers dark energy, causing a collapse after its starting explosion.

The Big Bang
This is the starting pistol of our universe. We do not know what happened before this colossal explosion, nor the its cause of it.

Current understanding of our universe

Our cosmos is thought to be flat, but further research may suggest we're wrong

Prof. Andrew Connolly

Andrew Connolly is a professor at the University of Washington, who focuses his time on conducting large surveys dedicated to investigating the evolution of galaxies and the cosmology of the universe. Understanding the true nature of the cosmos can reveal its most distant past, and possibly even its birth.

We'll get to know dark energy a bit better

"Some people think about a dark energy that changes with time, or whether the properties of the dark energy are different depending on where you look on the sky. Others make changes to the physics at the sub-atomic level, or they say our universe is just one of many: part of this mysterious multiverse. All of these theories, amazing and admittedly some of them a little crazy, all of them are consistent with our data.

"So how can we hope to make sense of this over the next decade? Well, imagine if I gave you a pair of dice, and I said I wanted you to see whether those dice were loaded or fair. One roll of the dice would tell you very little, but the more times you rolled them, the more data you collected, the more confident you would become – not just whether they're fair, but by how much, and in what way.

"With the LSST, we get a completely new view of the skies above Chile every three nights. In its first night of operation, it will find ten-times the number of supernovae used in the discovery of dark energy. This will increase by 1,000 within the first four months: 1.5 million supernovae by the end of its survey. Each supernova will test which theories of dark energy are consistent, and which are not. By combining this supernova data with other measures of cosmology we'll progressively rule out the different ideas and theories of dark energy until hopefully, at the end of this survey, we would expect to see a theory for our universe, a fundamental theory for the physics of our universe, to gradually emerge."

> "I believe an era of major discovery is inevitable" **Barry Barish**

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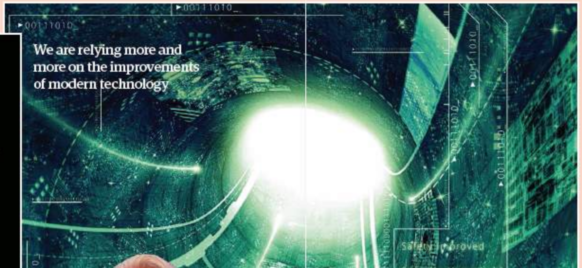
It'll be like we're living in *The Matrix*

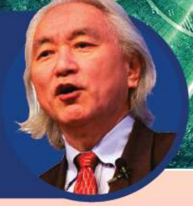
"When making predictions, I have two criteria: the laws of physics must be obeyed and prototypes must exist that demonstrate 'proof of principle'. I've interviewed more than 300 of the world's top scientists, and many have allowed me into laboratories where they are inventing the future. Their accomplishments and dreams are eye-opening. From my conversations with them, here's a glimpse of what to expect in the coming decades.

"According to Moore's Law, computer power doubles every 18 months. That means in a decade or so, chips will cost about a penny – the cost of scrap paper. Computers as we know them will disappear: they will be everywhere and nowhere, ubiquitous yet hidden, just like electricity and running water. The cloud will follow us silently and seamlessly, carrying out our wishes anytime, anywhere.

"Remember the movie *The Matrix*, where virtual information popped up to help inform physical day-to-day reality? Such things won't always be the stuff of Hollywood. If the internet is accessible via contact lenses, biographies will appear next to the faces of the people we talk to, and we will see subtitles if they speak a foreign language. (College students taking final exams will be among the first to buy internet contact lenses.) These lenses would revolutionise the lives of actors, politicians, surgeons, tourists, soldiers and astronauts by delivering maps, scripts, speeches, translations, biographies and charts with the blink of an eye."



We are relying more and more on the improvements of modern technology



Dr Michio Kaku

Michio Kaku is a Japanese-American theoretical physicist, and his work in communicating the complex issues within physics, and related topics, have led him to work with an array of international companies including the BBC, Discovery, CNN and the History Channel.

Prof. Jim Al-Khalili

Jim Al-Khalili is a British-Iraqi theoretical physicist, author and broadcaster. Not only is he a professor at the University of Surrey, but he also spreads scientific knowledge across all platforms of the BBC and other British media. He was awarded an OBE in 2008.

Artificial intelligence and augmented reality will completely take over

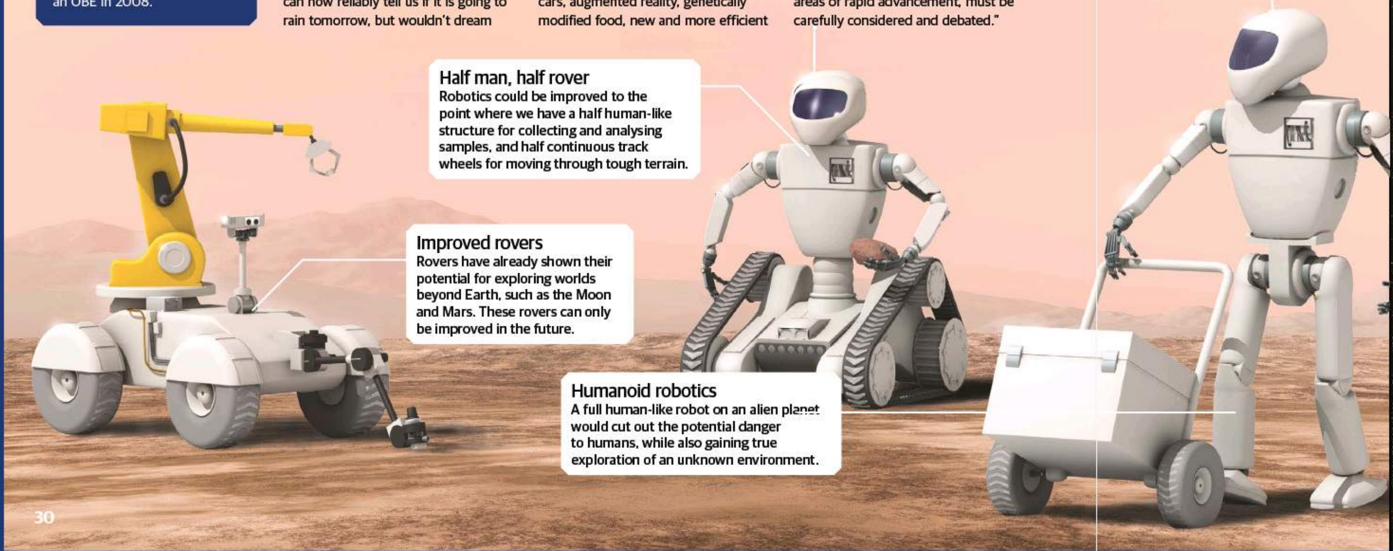
"Predictions about the way in which our lives will change thanks to advances in science and technology are spread across the wide expanse between the inevitable and the completely unexpected. The most reliable, and imaginative, soothsayers when it comes to conjuring up the future are usually science fiction writers, but very few of them before 1990 predicted the internet.

"However, just as meteorologists can now reliably tell us if it is going to rain tomorrow, but wouldn't dream of forecasting whether it will rain on this date next year, it is much easier to predict the technology of the next decade than that of a century. This is because the technology of tomorrow relies on the science of today.

"It is important to remember that scientific knowledge itself is neither good nor evil – it's the way we use it that matters. You can be sure that within a decade or two we will have AI controlled smart cities, driverless cars, augmented reality, genetically modified food, new and more efficient forms of energy, smart materials and a myriad of gadgets and appliances, all networked and talking to each other. It will be a world almost unrecognisable today, just as today would be to someone transported in a time machine here from the 1970s or 1980s.

"It is undeniably true that the implementation of new technologies, whether in AI, robotics, genetics, geoengineering or nanotechnology, to name but a few exciting current areas of rapid advancement, must be carefully considered and debated."

> "Scientific knowledge itself is neither good nor evil – it's the way we use it" **Jim Al-Khalil**



Half man, half rover
Robotics could be improved to the point where we have a half human-like structure for collecting and analysing samples, and half continuous track wheels for moving through tough terrain.

Improved rovers
Rovers have already shown their potential for exploring worlds beyond Earth, such as the Moon and Mars. These rovers can only be improved in the future.

Humanoid robotics
A full human-like robot on an alien planet would cut out the potential danger to humans, while also gaining true exploration of an unknown environment.

Why the universe is accelerating

"I have to remind everybody: nobody knows what the next big thing is going to be!

"When I graduated from engineering school [Cornell University], it was believed that the universe was what was called mathematically and uniquely flat. The universe would expand, and expand and expand, but never stop expanding. It was believed that the universe would never stop expanding, but always be slowing down, and people were trying to analyse that. They discovered that the universe isn't slowing down, it's speeding up. In fact, it's accelerating.

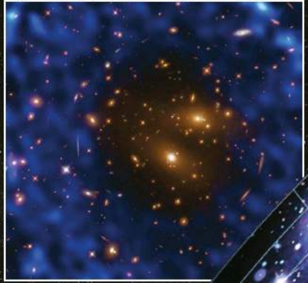
"And do you know why? Nobody knows why. So that could lead to some astonishing discovery that would change the course of history, the way Einstein did with relativity.

"I want to know why the universe is accelerating. That's a big deal for me, because I suspect it's the next relativity, it's the next classical physics, it's the next world-changing discovery. By looking for this thing, you will make discoveries.

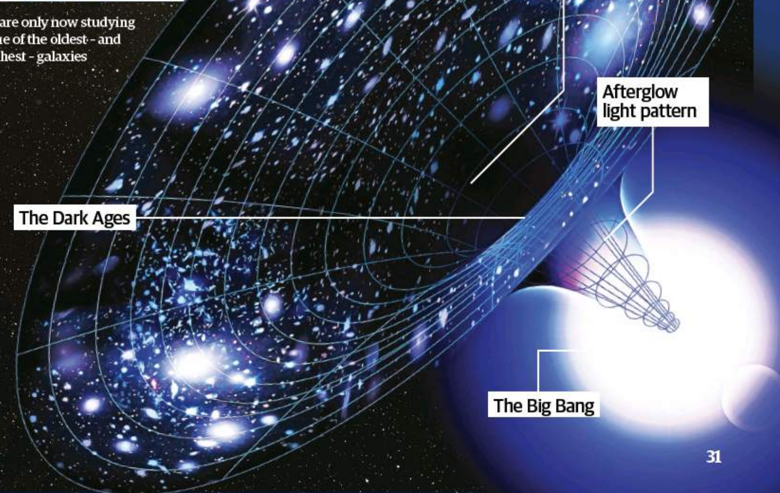
"You don't know what the next big thing is going to be. But when you have all these people [in the world] – 7.6 billion people – if we can give another couple of billions of those access to the internet, it will change the world."

Bill Nye

William Sanford Nye, more commonly known as Bill Nye the Science Guy, is a renowned science communicator in the United States. His many television appearances have inspired countless people. During his time at Cornell University, he took an astronomy class that was taught by the equally famous Carl Sagan.

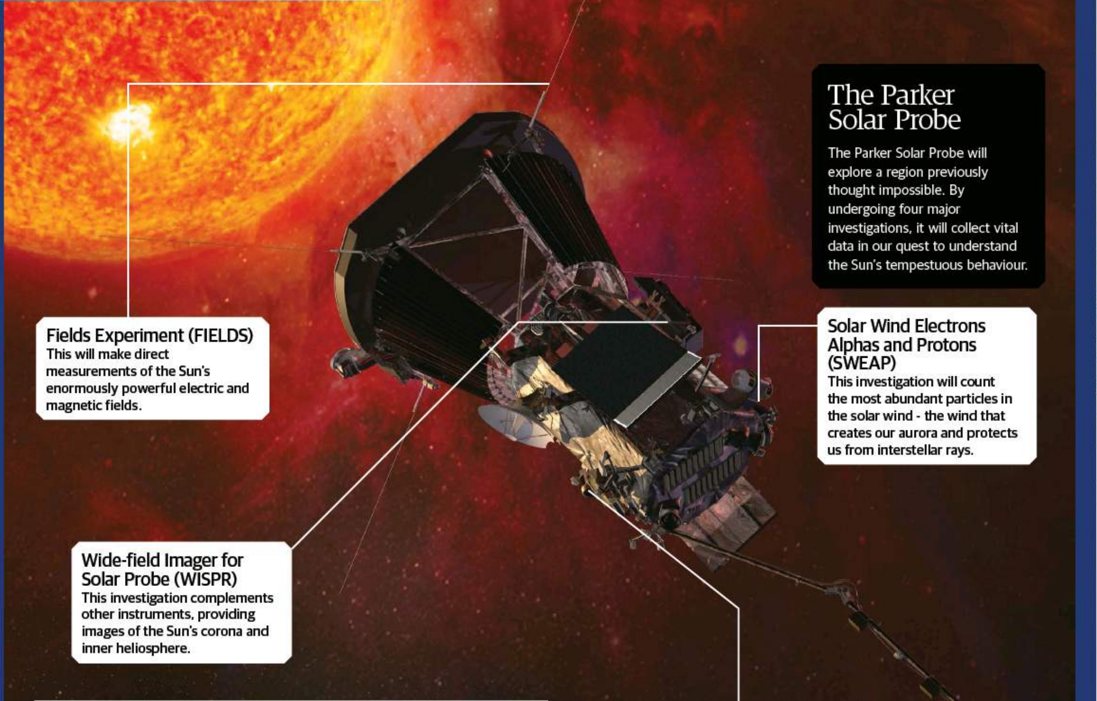


We are only now studying some of the oldest - and furthest - galaxies



The universe as we see it today
Formation of the first stars and galaxies
Afterglow light pattern
The Dark Ages
The Big Bang

© NASA, ESA, Adrian Mann; Peter and Zabransky



The Parker Solar Probe

The Parker Solar Probe will explore a region previously thought impossible. By undergoing four major investigations, it will collect vital data in our quest to understand the Sun's tempestuous behaviour.

Fields Experiment (FIELDS)
This will make direct measurements of the Sun's enormously powerful electric and magnetic fields.

Solar Wind Electrons Alphas and Protons (SWEAP)
This investigation will count the most abundant particles in the solar wind - the wind that creates our aurora and protects us from interstellar rays.

Wide-field Imager for Solar Probe (WISPR)
This investigation complements other instruments, providing images of the Sun's corona and inner heliosphere.

Integrated Science Investigation of the Sun (ISIS)
ISIS will collect information with regards to the Solar Energetic Particles (SEPs), including electrons, protons and heavy ions.

We'll make some huge discoveries about our Sun

"I'm most excited about the discoveries we're going to make about the Sun in the next couple of years, because we've been waiting almost six decades to learn how our star truly works. Back in the 1930's, scientists determined the temperature of the solar corona must be over a million degrees Celsius [over 1.8 million degrees Fahrenheit] – 300-times hotter than the Sun's surface. In 1958, Dr. Eugene Parker proposed a number of concepts about a flow of energy emanating from the Sun, which he called the 'solar wind.'

"He described an entire complex system of plasmas, magnetic fields and energetic particles that make up this phenomenon, and he later even theorised an explanation for the superheated corona: nanoflares. But until now, we've never been able to answer some fundamental questions about the Sun: Why is the solar corona so much hotter than the photosphere, and how is the solar wind accelerated?

"To find out, we must sample the heart of the corona – a feat only possible thanks to recent advanced technology developments. In 2018, NASA will launch its Parker Solar Probe to hurtle through the Sun's atmosphere, facing brutal heat and radiation. Over its seven-year mission, the probe will journey through the corona 24 times, eventually passing within 4 million miles [6.4 million kilometres] of the surface. Scientists will use the spacecraft's breakthrough datasets to answer those fundamental questions. Once we do that, we can make transformational improvements in our ability to predict solar wind and space weather conditions that impact Earth and our modern society."

> "Until now, we've never been able to answer some fundamental questions about the Sun" Nicola Fox

Dr. Nicola Fox

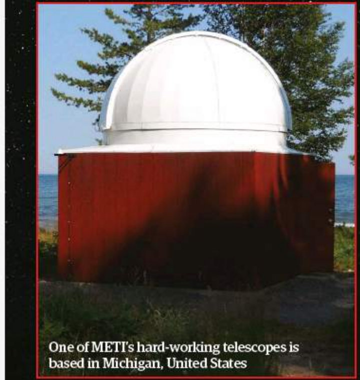
Nicola Fox is a chief scientist at the Johns Hopkins University Applied Physics Laboratory. She is a project scientist for NASA's Parker Solar Probe that is due to launch in 2018, so she will be one of the first scientists to analyse the long-awaited data that could reveal the secrets of the Sun.

© NASA ESA

Communicating with the unknown

One of the Search for Extraterrestrial Intelligence (SETI)'s focused institutes, Messaging Extraterrestrial Intelligence (METI) International, has now taken a much more active approach by messaging a nearby star with a potentially habitable planet

Interviewed by Lee Cavendish



One of METI's hard-working telescopes is based in Michigan, United States

Where did you send the message from?

We chose the 'EISCAT' transmitter, which is the 'European Incoherent Scatter Scientific Association' in Tromsø, Norway. It's located north of the Arctic Circle, and one of the phenomenon they look at is the Northern Lights, or Aurora Borealis. The facility operates by transmitting radio signals and studying them as a small percentage of them bounce back to Earth, but it can also be used to target the stars. It's a powerful system, and there are a couple of different transmitters there - we used the 32-metre completely steerable parabolic dish.

Is there a particular reason why you chose October to send it?

We chose October because it is an ideal time of the year, and so is April - when we will go back for a second round of transmission - because the apparent distance between the Earth and the Sun is maximised. So it's a nice geometry from the perspective of any intelligence around Luyten's Star, and that was really a key consideration when we designed the project. We thought about what we had to do to make this as detectable as possible, if there are SETI scientists watching us from that star.

About the target itself, why did you select Luyten's Star as your intended target?

We chose Luyten's Star, also known as GJ 273, because it is the closest star that's visible from the EISCAT transmitter that has known, potentially habitable exoplanets.

Luyten's Star, has two known exoplanets. One of them, GJ 273b, is a super-Earth. It is roughly three-times the mass of Earth, and it is at the right distance from its star that it could support liquid water. Also, an interesting thing about Luyten's Star is that it's a red dwarf star, which is one of a majority of red dwarf stars in our galactic neighbourhood.

Historically within the SETI community, red dwarfs have been written off. The idea was that red dwarfs are a horrible place to look for life, because any planet that is close enough to the star might be tidally locked. The star itself [Luyten's Star] is a red dwarf; it's a M-class star. Its mass is less than a third the mass of the Sun, which means it doesn't burn as brightly. So, in order to get enough radiation to support liquid water, the planet GJ 273b needs to be much closer than the Earth is to our Sun.

The problem with that is, in the same way as when we look up in sky and see the Moon, we always see the same side of the Moon because it's tidally locked. That may be the case with GJ 273b and, until recently, astronomers had said: "Well, that's a deal breaker for life. One side would be completely toasted, and one side would be frozen. You couldn't have life there, even if it's the right distance."

However, in recent years, there's been some interesting modelling of the transfer of heat through oceans and atmospheres. It suggests that even a tidally locked planet may be habitable. To take a local example, when the Sun sets on the Golden Gate Bridge here in San Francisco tonight, I'm not worried that San Francisco bay is going to freeze over, as we have this transfer of heat here. It would have to be a stronger mechanism on a tidally locked planet such as GJ 273, but it's possible.

So our goal of choosing was - here is an exoplanet that might be habitable, and it is close. I think the biggest obstacle of sending intentional messages to try to get a response is simply that time delay. In the best-case scenario, we get a reply back in 25 years, and that's with a relatively close star, so we put a premium on stars that are close to Earth as possible.

What is encrypted in the message, and how do you think alien intelligence will come to understand it?

The message is distinct from previous interstellar messages, insofar as it is designed to communicate a few things in greater depth, as opposed to trying to cover a wide range of topics.

For an example of past messages, I think the most famous radio message is one transmitted in 1974 from the Arecibo radio telescope in Puerto Rico. That was a brief message, but it was really encyclopaedic. It started with a description of a numbering system, then identified five chemical elements important to life on Earth. It gave a description of the shape and chemical composition of our DNA, a diagram of a human being in silhouette form, the population of the Earth, the height of a human being, a diagram of our Solar System, a silhouette of the telescope and the dimensions of the telescope it was transmitted by. My concern is, if you try and communicate too

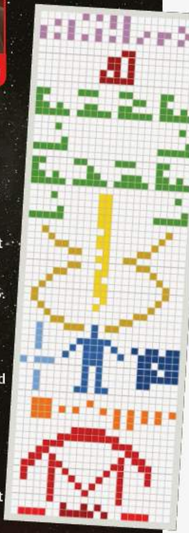
> "[The signal] is designed to communicate a few things in greater depth, as opposed to trying to cover a wide range of topics"

INTERVIEW BIO

Dr Douglas Vakoch

Born in Minnesota, United States in 1961, Dr Douglas Vakoch is currently president of Messaging Extraterrestrial Intelligence (METI) International. An institute of SETI, this is a non-profit organisation that is dedicated to the active search for extraterrestrial intelligence, formed in 2015.

An ongoing debate regarding the ethics of actively messaging intelligent alien life forms has not stopped Vakoch and the rest of METI. Recently, they have sent a radio signal from a transmitter in Norway to Luyten's Star, also known as GJ 273, which has a potentially habitable planet just 12 light years away from Earth.



The Arecibo message was sent to the globular cluster M13, also known at the Hercules Globular Cluster

The EISCAT transmitter is normally used to study the upper atmosphere, including the Aurora Borealis

© NASA; Per Bifrost; Arne Nordmann

much, it can become very confusing. So we took the opposite approach and sent a message that is directly related to the signal itself.

We [METI] are focused on some of the characteristics of the only thing that we have in common with the extraterrestrials, which is the signal itself. We asked ourselves: "What is it that we and the extraterrestrials have in common, in order for them to be able to detect our signal well, if they could detect our signal?"

We know that they [must] have built a radio receiver, and so it seems likely that you'll need to know at least some fundamental principles of mathematics. If you can't add one plus one to get two, you're probably not going to be a very good engineer on GJ 273b or on Earth.

That's the starting point, but then the difference between our message and past messages that have been sent is that we've attempted to be incremental in our approach.

Some of the fundamental properties, for example, would be the notion of time. Communicating time by sending signals at various durations, and then describing that mathematically. Similarly, when we talk about frequency, we do so by reference to the two different frequencies that the ones and zeros are encoded in, 929 MHz and 930.2 MHz.

It's more ambitious, because our goal is to have a good chance of communicating at least something.

For the benefit of our readers, could you explain what METI [Messaging Extraterrestrial Intelligence] International is and what its current goals are?

METI was founded in 2015 to take on the projects in astrobiology and SETI that weren't being taken on by other organisations. The project that we're most known for, just given our name, is sending intentional messages to other civilizations. We're interested in other areas too, which some of the existing organisations - the SETI Institute, Harvard University, the Berkeley SETI crew or other major universities around the world - involved in astrobiology simply aren't doing.

So within SETI, the mindset has typically been to get as large a telescope as you can and use it as much of the time as you can. Instead, our strategy is to use smaller telescopes and more of them, so we're beginning a network of optical telescopes, as we now have one in Panama and one in Michigan [United States].

We've [METI International] also really emphasised from the outset an international focus. So, half of our board of directors is outside the US, and we have people from, I think, 16 countries on our advisory council, as it's important to have engineers and astronomers that have always been essential to interstellar communication.

As you mentioned the SETI Institute previously, I understand that you worked for them for about 16 years. Is that true?

That is correct.

What made you separate from the SETI Institute and focus primarily upon the intentionally messaging aspect?

Because I thought it was an area that offers a new opportunity. I view active SETI, or sending intentional messages, as a natural outgrowth. Much like optical SETI [SETI conducted in optical wavelength observations] was an outgrowth in its early days.

And you know; every organisation needs to set its priorities. No organisation can do everything.

Red dwarf stars are abundant in our galaxy, making them likely candidates for hosting appropriate exoplanets

METI's radio message was sent in October 2017 from the EISCAT transmitter in Tromsø, Norway

Luyten's Star, also known as GJ 273, is just 12 light years away from us

© Danielle Futselaar/METI; D. Aguilar/Harvard-Smithsonian Center for Astrophysics; Scanmap

> "What is it that we and the extraterrestrials have in common, in order for them to be able to detect our signal"

METI has an observatory based in Panama dedicated to firing messages into deep space

So at the SETI institute, the management decided they didn't want to go ahead with active SETI, but there were a number of us who felt like this is an important project, and if the existing organisations aren't taking it on, then we need to start something new that will.

What were the reasons the other SETI members gave as to why they didn't want to send a message?

I have heard a number of reasons. I think one of the most articulate answers as to why you shouldn't do active SETI comes from Jill Tarter, who has long stated that she doesn't think humankind is at a point where we are mature enough, or we can take a long-term perspective. It's something I'm sympathetic with. I think she's right that we haven't demonstrated that we can operate on multigenerational timescales, and so I can appreciate that.

As an organisation, you have only so many resources, so you have to decide where you're going to put them. I think the traditional mindset of doing research is that you need something that can have the possibility of a pay-off in the short term.

You don't usually think of science as something that takes decades, centuries or even millennia to test your hypothesis. So I think that's most fundamentally the mindset that we need to foster, and it doesn't naturally come out of doing astronomy. I think it does have some similarities to exoplanet research a quarter of a century ago, where we were looking for something that there was no guarantee was out there. But unless we run the experiment, we won't know.

What protocols do you have in place in case there is contact one day?

Well our protocols are the same protocols that have been developed over the last several decades in the SETI community, which are twofold. First of all, confirm that you really have detected a signal, and then, secondly, tell the whole world.

I think that second part - tell the whole world - will happen automatically. Simply by the process of confirming, that means you check with other observatories, and by the time you really have a solid confirmation, I think the world would know anyway.

The most challenging part is to really confirm that you have a signal. That's one of the features we included in the design of this transmission to GJ 273b. We really need to think about what we [METI] need to do so that extraterrestrial scientists that are following the kind of protocol that we use can really be assured that they've got the signal.

Our mathematical tutorial is a little over three, maybe three and a half minutes. Each day that we transmitted it in October, we repeated it three times. We sent it three times in a row, and then 24 hours later we sent it again three times, and then 48 hours later we sent it again. That's to allow the extraterrestrials to have a little additional time to contact colleagues so they can get a confirmation. To give them a bit more time for confirmation, we'll be going back six months later in April.

Do you think we'll get a reply from Luyten's Star within the next 50 years?

Realistically, I think that 50 years is too early to get a reply. It is conceivable that we get a reply back from Luyten's Star. You know, one explanation for the Fermi paradox - if they're out there, why haven't we seen anyone - is the zoo hypothesis, where in fact, we're being watched like animals at the zoo.

But what happens if the zebra turns towards you and starts pounding out a series of prime numbers? That's what we're trying to do to see if we can get a response back. However, in order for that to work when we target just one star, it [hypothetically] means that virtually every star is populated. So the Milky Way is [hypothetically] chock full of intelligent life just waiting for an invitation. I hope that's the case, but I think more realistically we need to repeat this a hundred times, a thousand times or even a million times [before we manage to make some kind of contact].

I believe that the more realistic case is that we need to head towards the thousand or the million stars. In that case, it is going to be centuries, or even millennia, until we get a reply back. So I'm not holding my breath in either case.

Titan quadcopter

NASA's innovative proposal to send a robotic dragonfly to scout Saturn's largest moon

One of NASA's most impressive current projects is the Curiosity Mars rover. The 899-kilogram (1981-pound) nuclear-powered rover is a travelling laboratory, which was landed on the Red Planet's surface by a rocket-powered sky crane in 2012. However, it is no simple matter to navigate a $2.5 billion rover on another world. As a result, Curiosity moves very cautiously, crawling along at up to 200 metres (656 feet) per day, travelling 17.81 kilometres (11.06 miles) as of sol 1891, which equates to around five Earth years. This inevitably limits the reach of such missions, and will be even more challenging on our next landing targets - the large moons of Jupiter and Saturn. The most interesting of these moons, Saturn's Titan, offers an unique opportunity in the Solar System.

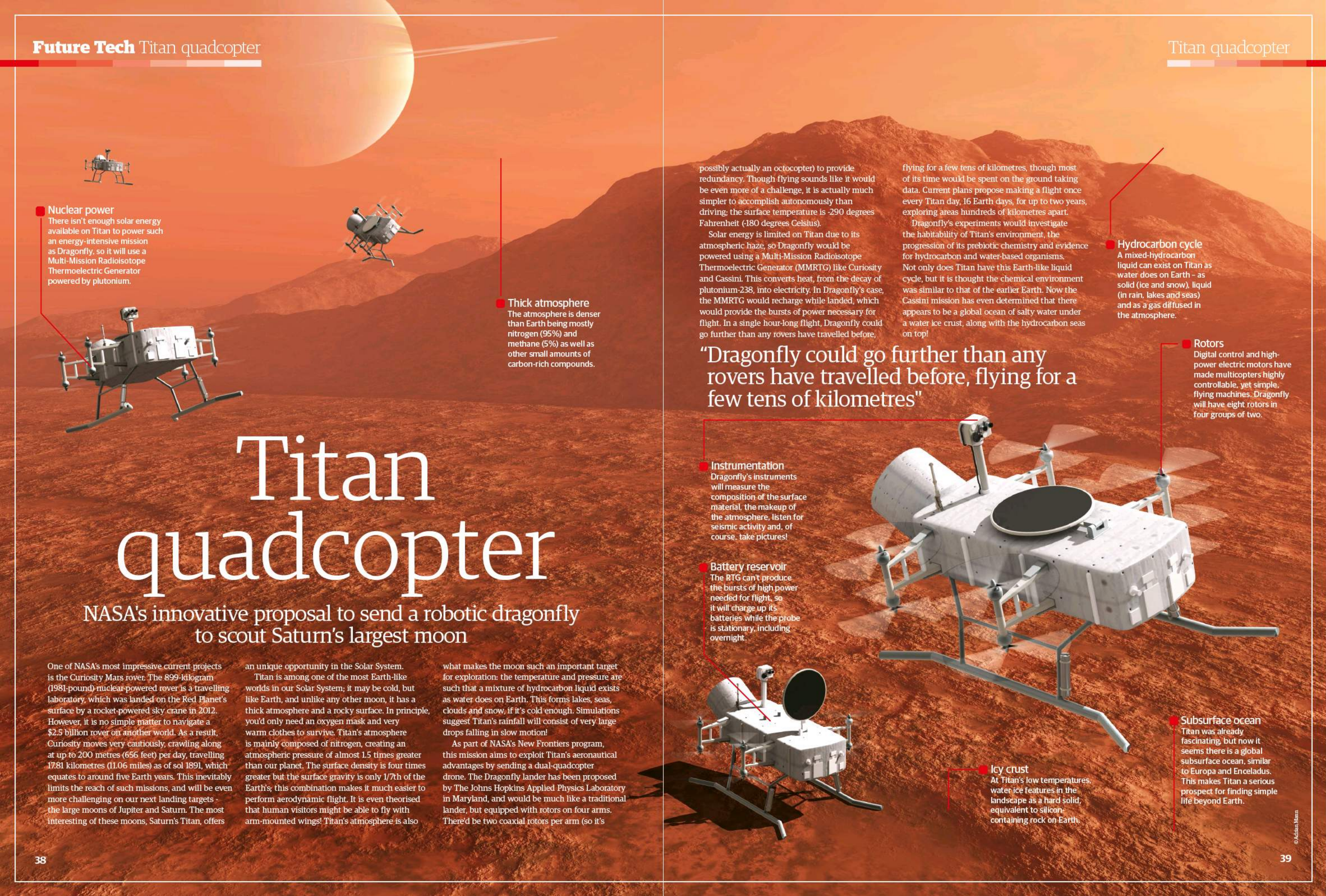
Titan is among one of the most Earth-like worlds in our Solar System; it may be cold, but like Earth, and unlike any other moon, it has a thick atmosphere and a rocky surface. In principle, you'd only need an oxygen mask and very warm clothes to survive. Titan's atmosphere is mainly composed of nitrogen, creating an atmospheric pressure of almost 1.5 times greater than our planet. The surface density is four times greater but the surface gravity is only 1/7th of the Earth's; this combination makes it much easier to perform aerodynamic flight. It is even theorised that human visitors might be able to fly with arm-mounted wings! Titan's atmosphere is also what makes the moon such an important target for exploration: the temperature and pressure are such that a mixture of hydrocarbon liquid exists as water does on Earth. This forms lakes, seas, clouds and snow, if it's cold enough. Simulations suggest Titan's rainfall will consist of very large drops falling in slow motion!

As part of NASA's New Frontiers program, this mission aims to exploit Titan's aeronautical advantages by sending a dual-quadcopter drone. The Dragonfly lander has been proposed by The Johns Hopkins Applied Physics Laboratory in Maryland, and would be much like a traditional lander, but equipped with rotors on four arms. There'd be two coaxial rotors per arm (so it's possibly actually an octocopter) to provide redundancy. Though flying sounds like it would be even more of a challenge, it is actually much simpler to accomplish autonomously than driving; the surface temperature is -290 degrees Fahrenheit (-180 degrees Celsius).

Solar energy is limited on Titan due to its atmospheric haze, so Dragonfly would be powered using a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) like Curiosity and Cassini. This converts heat, from the decay of plutonium-238, into electricity. In Dragonfly's case, the MMRTG would recharge while landed, which would provide the bursts of power necessary for flight. In a single hour-long flight, Dragonfly could go further than any rovers have travelled before, flying for a few tens of kilometres, though most of its time would be spent on the ground taking data. Current plans propose making a flight once every Titan day, 16 Earth days, for up to two years, exploring areas hundreds of kilometres apart.

Dragonfly's experiments would investigate the habitability of Titan's environment, the progression of its prebiotic chemistry and evidence for hydrocarbon and water-based organisms. Not only does Titan have this Earth-like liquid cycle, but it is thought the chemical environment was similar to that of the earlier Earth. Now the Cassini mission has even determined that there appears to be a global ocean of salty water under a water ice crust, along with the hydrocarbon seas on top!

> "Dragonfly could go further than any rovers have travelled before, flying for a few tens of kilometres"



Nuclear power
There isn't enough solar energy available on Titan to power such an energy-intensive mission as Dragonfly, so it will use a Multi-Mission Radioisotope Thermoelectric Generator powered by plutonium.

Thick atmosphere
The atmosphere is denser than Earth being mostly nitrogen (95%) and methane (5%) as well as other small amounts of carbon-rich compounds.

Hydrocarbon cycle
A mixed-hydrocarbon liquid can exist on Titan as water does on Earth – as solid (ice and snow), liquid (in rain, lakes and seas) and as a gas diffused in the atmosphere.

Rotors
Digital control and high-power electric motors have made multicopters highly controllable, yet simple, flying machines. Dragonfly will have eight rotors in four groups of two.

Instrumentation
Dragonfly's instruments will measure the composition of the surface material, the makeup of the atmosphere, listen for seismic activity and, of course, take pictures!

Battery reservoir
The RTG can't produce the bursts of high power needed for flight, so it will charge up its batteries while the probe is stationary, including overnight.

Icy crust
At Titan's low temperatures, water ice features in the landscape as a hard solid, equivalent to silicon-containing rock on Earth.

Subsurface ocean
Titan was already fascinating, but now it seems there is a global subsurface ocean, similar to Europa and Enceladus. This makes Titan a serious prospect for finding simple life beyond Earth.

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WHY IS OUR MILKY WAY SO WEIRD?

Finding out may help solve some of the universe's biggest mysteries

Written by Colin Stuart

Imagine you're marooned deep inside a vast forest. A canopy of trees stretch as far as your eyes can see, and leaves rustle at your feet as you explore your surroundings. Eventually you realise the wood is so big that you can never make it out. Then imagine trying to decipher what the giant forest would look like from the outside and how that compares to other wooded areas far beyond, where you can also never travel to.

This unenviable task is similar to the experience of astronomers trying to understand our Milky Way galaxy in the context of the wider universe. At least 100,000-light-years across, and 1,000 light-years thick, we have no prospect of leaving our forest of stars any time soon. Thanks to telescopes, we can see into deeper parts of the galaxy, and even glimpse other far off galaxies, but we can never visit those either. So discovering how our Milky Way galaxy compares to others is no easy task - being trapped inside it is both a help and a hindrance. "Some things are easier to find out and some things are harder," says Karen Masters, from the Institute of Cosmology and Gravitation at the University of Portsmouth.

A real benefit is the ability to look at individual stars, measure their chemical abundances and watch their motion around parts of the galaxy. "You can dissect the Milky Way in a way that you can't do with other galaxies," Masters says. Yet learning about the properties of our galaxy as a whole entity can be tough. "We're out on one side of the Milky Way, so we can see our part of it quite easily," says Masters, "but seeing through the galactic centre to the other side of it is very challenging."

Getting over these hurdles really matters. "We use the Milky Way as a yardstick for the rest of the universe," says Marla Geha, from Yale University. "If it's not typical then we need to know," she says. Our knowledge of the Milky Way forms our understanding of the nature of dark matter, cosmology and galaxy formation.

Much of this information is gleaned from looking at the relationship between our galaxy and its set of smaller satellites - dwarf galaxies gravitationally bound to the Milky Way and orbiting around it. These include the Large and Small Magellanic Clouds largely visible from only the Southern Hemisphere. Yet Geha's latest research suggests that in this department, the Milky Way might be more of a freak than we'd previously realised.

Her project - the Satellites Around Galactic Analogs (SAGA) survey - aims to look at 100 galaxies like the Milky Way and study the dwarf galaxies that orbit them. That in itself is no mean feat. "Satellite galaxies look essentially identical to more distant background galaxies," she says. So how do you tell that you're really looking at a satellite galaxy? "By measuring their redshift," says Geha. As the universe expands, and the space between galaxies stretches, light travelling through space is also stretched out. This causes the light's frequency to shift towards the red end of the visible spectrum. The further away a galaxy, the more space there is between it and the Milky Way, and more of the light is redshifted on its way here.

Accurately measuring this redshift requires a lot of telescope time, making it very expensive. "We've been working at this for five or six years now," Geha says, "and we're very proud to have eight Milky-Way-like galaxies with satellites around them." She was surprised to find that almost all of them showed a fundamental difference to the Milky Way's satellites. "The satellite galaxies in seven out of eight of the systems were forming stars," she says. In contrast, the Milky Way is a much quieter galaxy; only a small fraction of its satellite galaxies form stars. "It was a surprise to us," admits Geha. It seems our galaxy's gravitational pull is stifling star formation in its satellites in a way that similar galaxies aren't. With only eight systems studied so far, the results from the SAGA survey are far from conclusive. But with a larger sample size, astronomers will be able to confirm whether the Milky Way really is as weird as it seems. We might also be able to say more about what our galaxy is doing to halt the creation of new stars in its neighbours.

The SAGA survey could also tell us something interesting about the nature of dark matter - the mysterious and shadowy substance thought to help glue galaxies together. It all hinges on the number of dwarf galaxies Geha and her colleagues find around each galaxy. "If we find that other galaxies have much fewer satellites than the Milky

> "We can see our part of it quite easily, but seeing through the galactic centre to the other side is very challenging" **Karen Masters**

Data from NASA's WISE mission suggests that the Milky Way has four spiral arms

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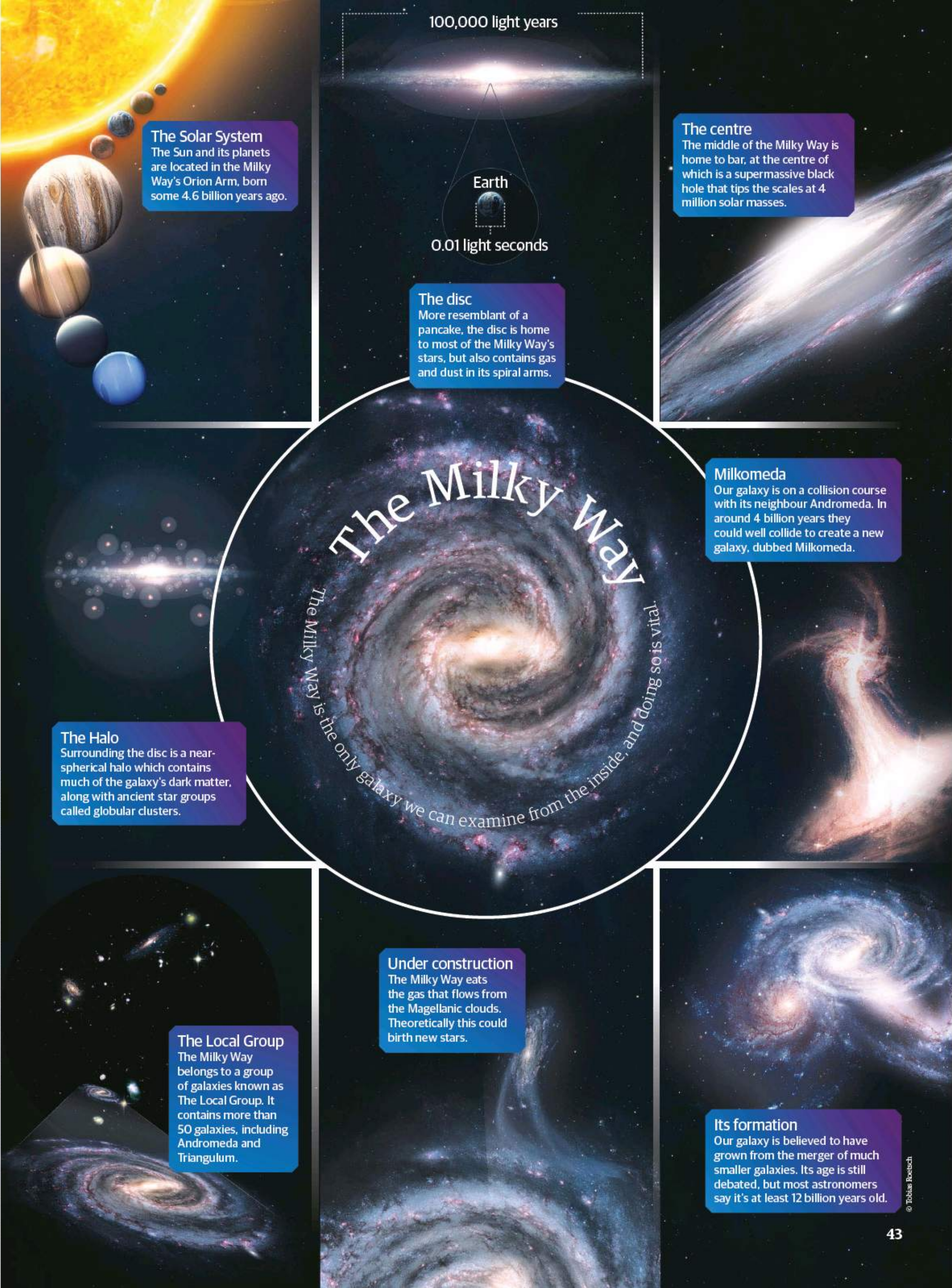

The Milky Way

The Milky Way is the only galaxy we can examine from the inside, and doing so is vital.

The Solar System
The Sun and its planets are located in the Milky Way's Orion Arm, born some 4.6 billion years ago.

The centre
The middle of the Milky Way is home to bar, at the centre of which is a supermassive black hole that tips the scales at 4 million solar masses.

The disc
More resemblant of a pancake, the disc is home to most of the Milky Way's stars, but also contains gas and dust in its spiral arms.

Milkomeda
Our galaxy is on a collision course with its neighbour Andromeda. In around 4 billion years they could well collide to create a new galaxy, dubbed Milkomeda.

The Halo
Surrounding the disc is a near-spherical halo which contains much of the galaxy's dark matter, along with ancient star groups called globular clusters.

Under construction
The Milky Way eats the gas that flows from the Magellanic clouds. Theoretically this could birth new stars.

The Local Group
The Milky Way belongs to a group of galaxies known as The Local Group. It contains more than 50 galaxies, including Andromeda and Triangulum.

Its formation
Our galaxy is believed to have grown from the merger of much smaller galaxies. Its age is still debated, but most astronomers say it's at least 12 billion years old.

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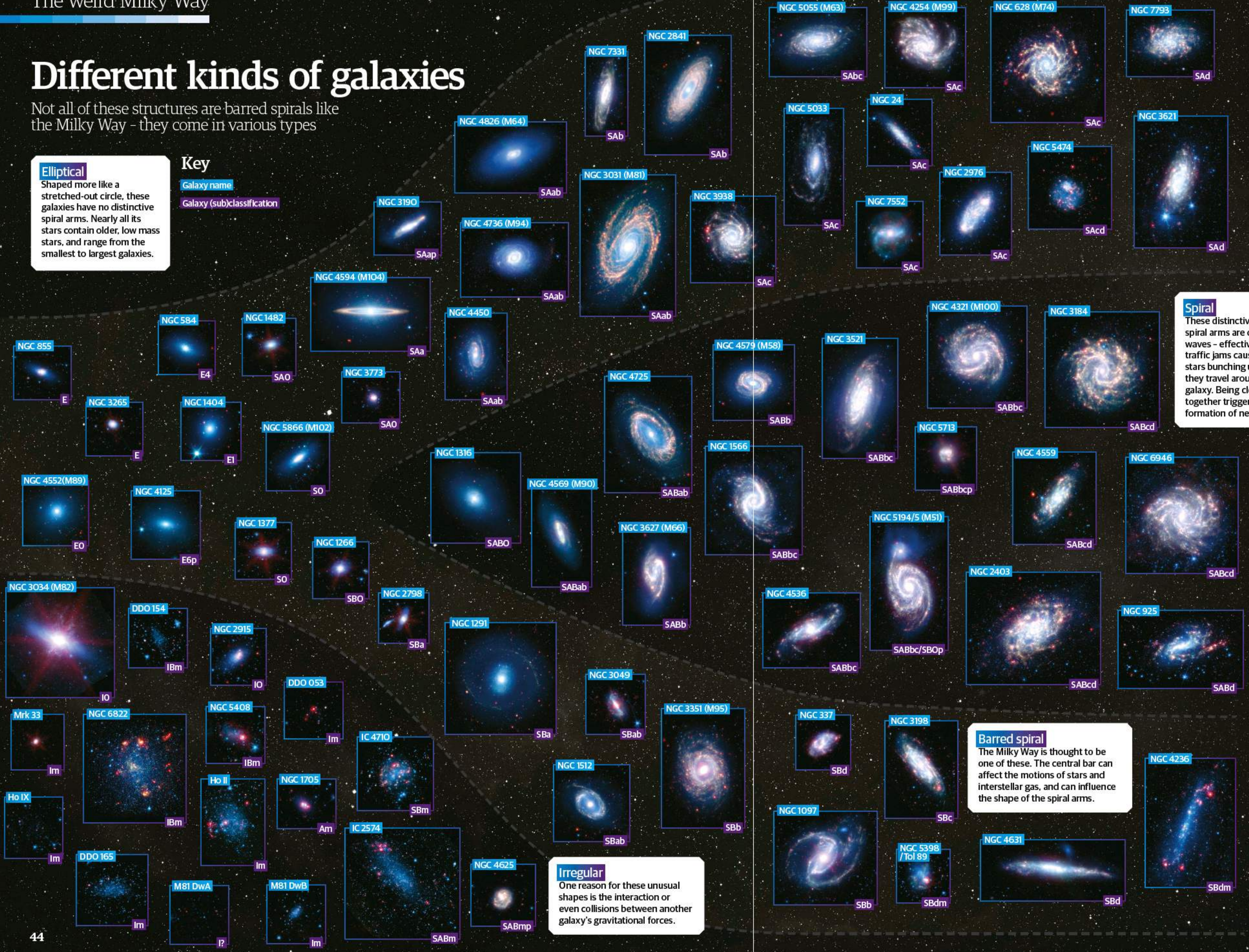
Different kinds of galaxies

Not all of these structures are barred spirals like the Milky Way – they come in various types



Elliptical
Shaped more like a stretched-out circle, these galaxies have no distinctive spiral arms. Nearly all its stars contain older, low mass stars, and range from the smallest to largest galaxies.

Spiral
These distinctive spiral arms are density waves – effectively traffic jams caused by stars bunching up as they travel around the galaxy. Being close together triggers the formation of new stars.

Barred spiral
The Milky Way is thought to be one of these. The central bar can affect the motions of stars and interstellar gas, and can influence the shape of the spiral arms.

Irregular
One reason for these unusual shapes is the interaction or even collisions between another galaxy's gravitational forces.

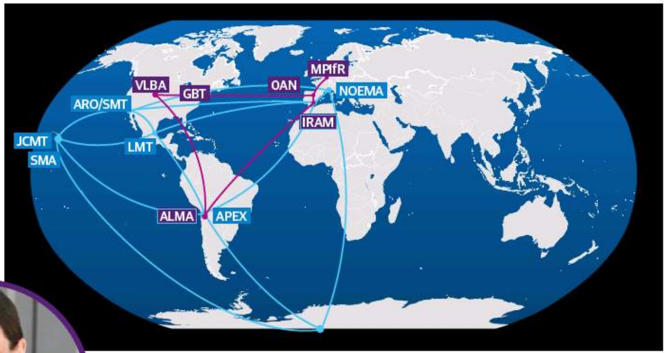
Way there's an argument that dark matter is not cold," she says. The leading cosmology of today is known as CDM (Lambda Cold Dark Matter), yet if dark matter is warmer than we think, Geha says it would have acted as an 'egg beater', stirring up the early universe and preventing as many smaller galaxies from forming. "We don't have many ways of figuring out the nature of what dark matter is," she says. "This is one way to get at that."

Geha's research is just one part of a growing body of evidence suggesting that our Milky Way is somewhat of an oddball, flying in the face of our traditional picture. Our galaxy appears to be a flat disc with spiral arms and its stars – including the Sun – orbit around the centre. That in itself is very run-of-the-mill. Except, from their study of other galaxies, astronomers have noticed a relationship between the speed at which a galaxy's stars rotate and the overall brightness of the galaxy. "There is some indication that the Milky Way isn't as bright [as it should be]," says Masters. Although she also cautions that the data behind this assumption is actually quite scattered.

Masters has been heavily involved in Galaxy Zoo – a citizen science project that enlists the help of members of the public to look at galaxies and help classify them. There are so many images of galaxies these days that astronomers simply cannot get through all of them without assistance. The human eye is much better at spotting patterns and things that are out of the ordinary rather than a computer programme. Among many successes, the project has helped identify the existence of so-called 'red spirals' – spiral galaxies with a much lower rate of star formation than typical spirals. After all, we only tend to see spiral arms because they are bright areas of a galaxy's disc picked out by hot, blue, young stars. "The Milky Way is not star forming very actively," says Masters. So it seems our galaxy might be one of these red spirals. That makes it somewhat of an outlier. "Only ten to twenty per cent of spirals are red," she says.

That isn't the only thing potentially unusual about the Milky Way's spiral arms. It is thought that our galaxy has a bar structure at the centre, which is where the spiral arms originate from. "Most barred spirals have two arms," says Masters, "but there's a debate as to whether the Milky Way has two or four spiral arms." In 2015, astronomers using data from NASA's Wide-field Infrared Survey Explorer (WISE) came out in favour of the

> "Most barred spirals have two arms, but there's a debate as to whether the Milky Way has two or four spiral arms" **Karen Masters**



By linking up telescopes across the globe, astronomers are looking to examine the Milky Way's central black hole using the Event Horizon Telescope

four-arm picture. The four proposed arms are called Perseus, Scutum-Centaurus, Sagittarius and Outer. If the Milky Way really does have this quartet then this would be another reason to think of our galaxy as a bit of a misfit.

In the middle of the Milky Way 26,000 light years away, along with its central bar, sits a supermassive black hole tipping the scales at a colossal four-million-times the mass of the Sun. Astronomers believe that nearly all large galaxies have this massive beasts at their heart, so nothing out of the ordinary there. It even seems to have the right mass. "Central black holes tend to be about four per cent of the mass of the galaxy they reside in, and that seems roughly in-line for the Milky Way," says Masters. Yet our black hole - dubbed Sagittarius A* (Sgr A*) - does seem to be remarkably quiet for a black hole. But Masters warns against getting too carried away. "There seems to be a cycle where they turn on and off," she says. Back in 2008, a team of astronomers announced they'd found evidence of Sgr A* flaring up 300 years ago and in 2014 it was announced that Sgr A* had experienced an increase in flare activity, so is the black hole currently in its more active phase?

It's an exciting time to be involved in black hole research, and the latest instruments could provide a sea of change in our understanding, allowing us to say more about how freakish our central black hole is. Recently, the giant computational telescope - the Event Horizon Telescope (EHT) - made its first observations of Sgr A*. The telescope is made by combining the power of radio telescopes across the world. This creates a telescope that is essentially equivalent to the size of the Earth. It is hoped it will provide a close-up view of the black hole's shadow - a dark region where light passing close to the black hole is bent back, but does not 'fall' in and instead bends around the unseen mass. The recent discovery of gravitational waves also gifts astronomers yet another way to peer into the darkness and learn about black holes. More data means a higher degree of confidence when comparing our black hole to those at the centre of other galaxies.

That's what it comes down to. We can only really say how freakish our Milky Way is if we're able to observe other galaxies in as much detail as we do our own. Masters is currently involved in the MaNGA (Mapping Nearby Galaxies at Apache Point Observatory) project, part of the Sloane Digital Sky Survey. "We make these 3D maps of nearby galaxies," she says. There's also a little side project to make sure they observe as many galaxies as possible that are in a similar mass range to the Milky Way. "Then we'll have a better comparison set for these questions about how odd the Milky Way is." Geha agrees that we're heading in the right direction: "I can't wait," she says. "The future is really exciting and bright in terms of really understanding where our galaxy lies in a cosmological context."

> "The future is bright in terms of really understanding where our galaxy lies in a cosmological context" **Marla Geha**

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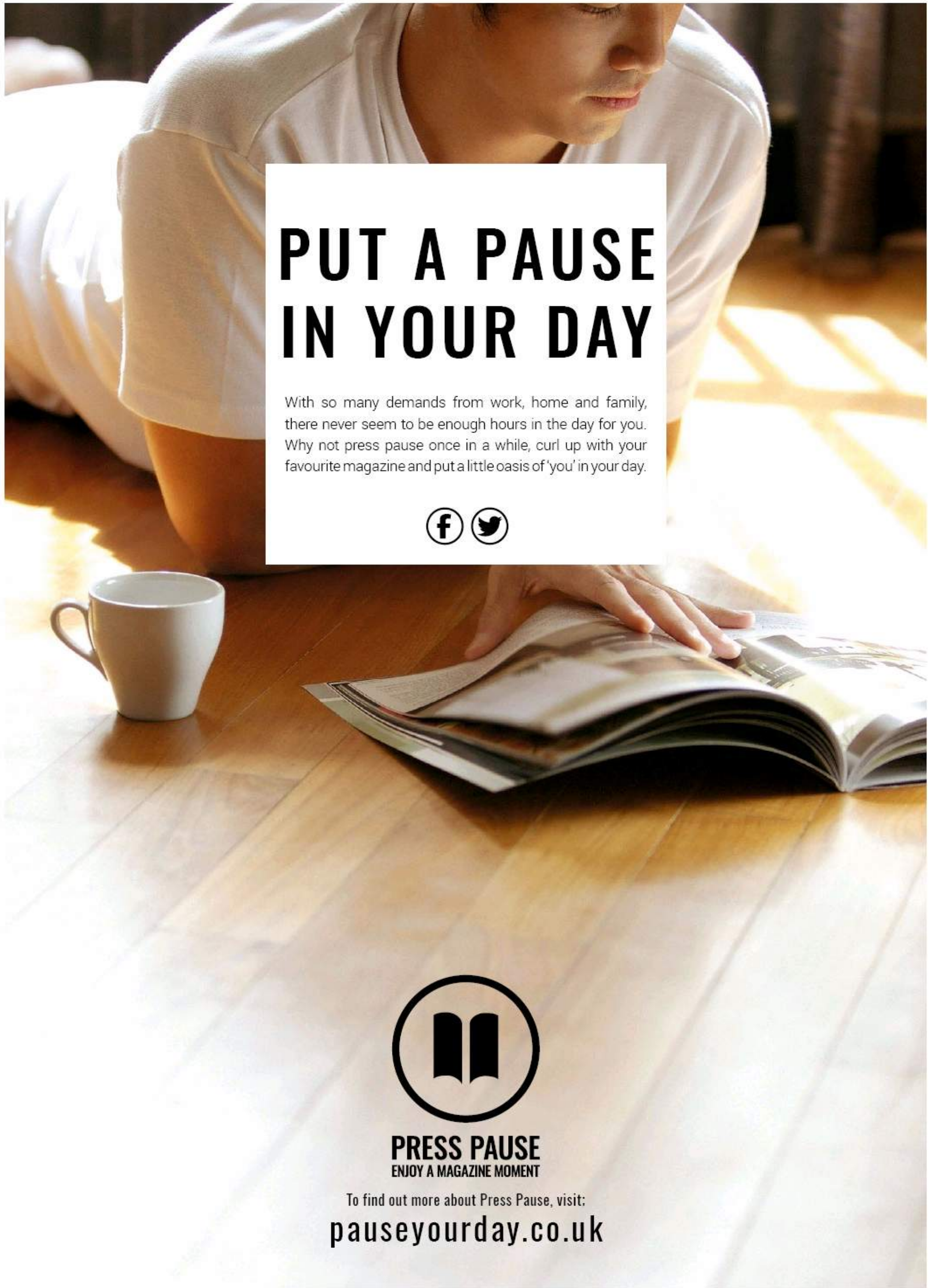

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LIGHT POLLUTION *ON THE RISE*

According to five years of satellite data, artificial light at night is rising by two per cent each year

Five years of images snapped by the joint NASA-NOAA Suomi National Polar-orbiting Partnership satellite has revealed that artificial light at night on Earth is getting brighter, rapidly growing at a rate of two per cent year upon year.

The landmark study, which was led by Christopher Kyba of the German Research Center for Geosciences (GFZ) in Potsdam, Germany, revealed that the increases were seen almost everywhere the team looked, with some of the largest gains in regions that were originally unlit. "Light is growing most rapidly in places that didn't have a lot of light to start with," notes Kyba. "That means that the fastest rates of increase are occurring in places that so far hadn't been strongly affected by light pollution."

It's expected that the ever-increasing upward trend in the use of outdoor lighting will continue, bringing a host of negative environmental consequences. "There is a potential for the lighting revolution to save energy and reduce light pollution," says Kyba of LED lighting, which requires significantly less electricity to yield the same quantity of light as older lighting technologies, "but only if we don't spend the savings on new light."

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Messier 76 in Perseus

Messier 34 in Perseus

Messier 45 in Taurus

Messier 79 in Lepus

Messier 42 in Orion

Messier 36 in Auriga

Messier 38 in Auriga

Messier 41 in Canis Major

Messier 93 in Puppis

Messier 47 in Puppis

Messier 95 in Leo

Messier 96 in Leo

Messier 105 in Leo

Messier 65 and Messier 66 in Leo

Messier 81 in Ursa Major

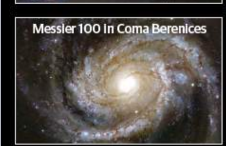
Messier 106 in Canes Venatici

Messier 94 in Canes Venatici

Messier 63 in Canes Venatici

Messier 51 in Canes Venatici

Messier 101 in Ursa Major


Messier 100 in Coma Berenices

Messier 85 in Coma Berenices

Messier 84 in Virgo

Messier 86 in Virgo

Messier 87 in Virgo

Messier 59 in Virgo

Messier 60 in Virgo

Messier 49 in Virgo

Messier 61 in Virgo

Messier 104 in Virgo

Messier 57 in Lyra

Messier 56 in Lyra

Messier 29 in Cygnus

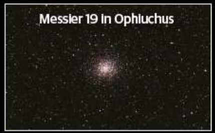
Messier 39 in Cygnus

Messier 27 in Vulpecula

Messier 9 in Ophiuchus

Messier 4 in Scorpius

Messier 80 in Scorpius


Messier 19 in Ophiuchus

Messier 62 in Ophiuchus

Messier 17 in Sagittarius

Messier 18 in Sagittarius

Messier 24 in Sagittarius

Messier 25 in Sagittarius

Messier 23 in Sagittarius

Messier 69 in Sagittarius

Messier 70 in Sagittarius

Messier 54 in Sagittarius

Messier 55 in Sagittarius

Messier 75 in Sagittarius

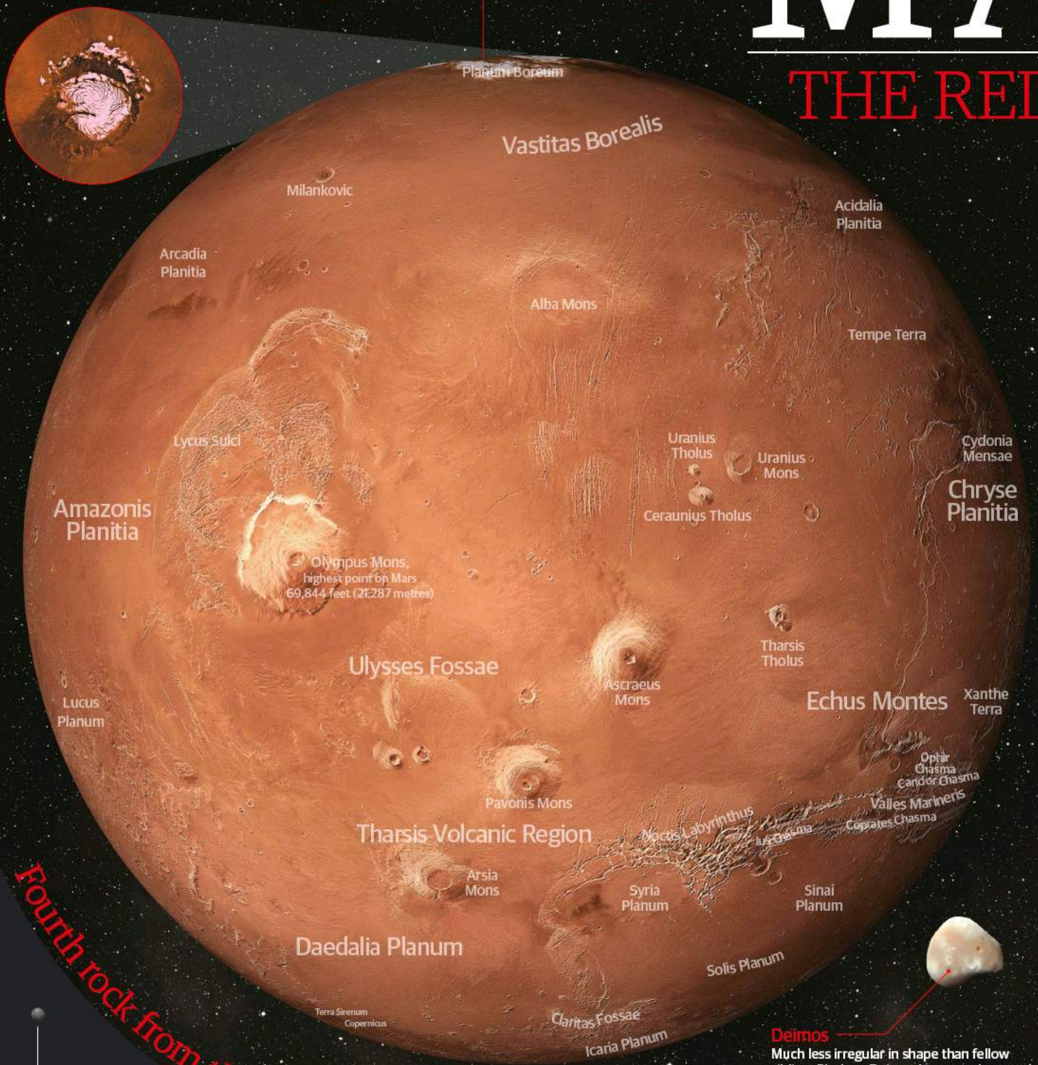
All About Space *presents*

MARS

THE RED PLANET

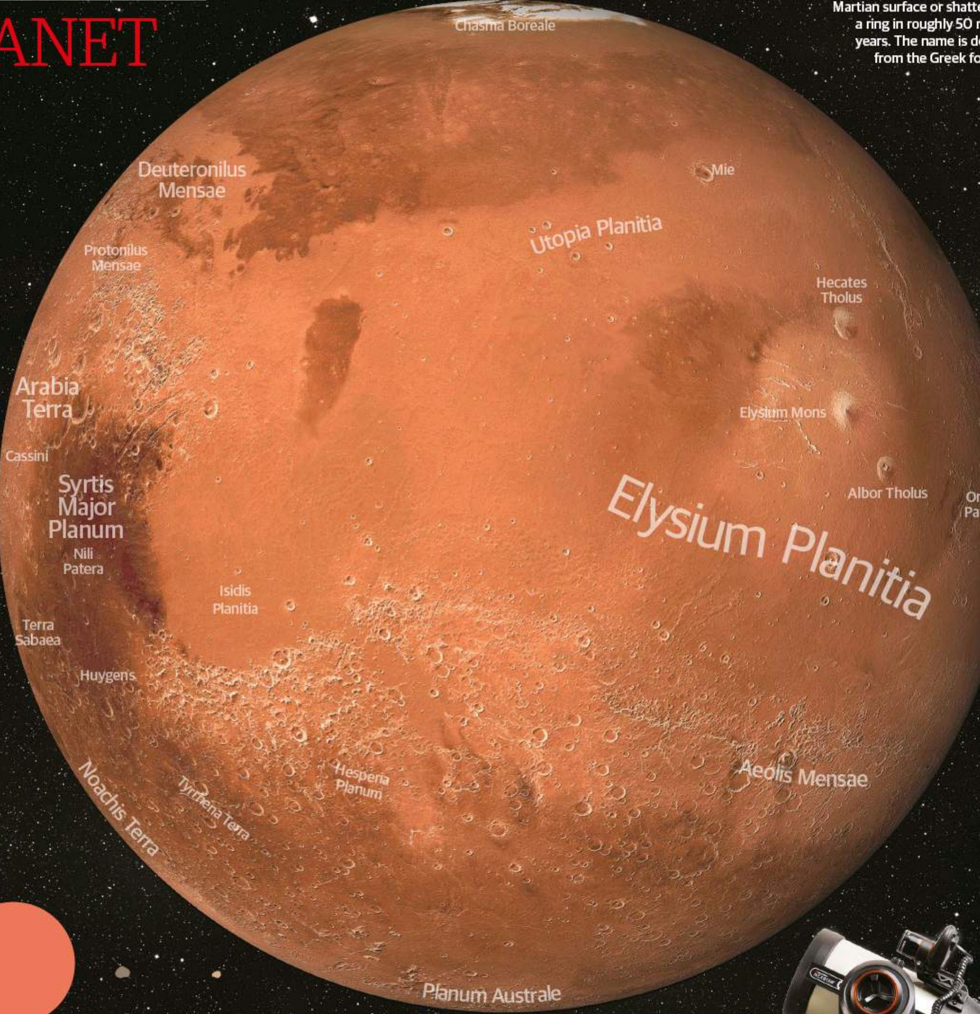
North pole

Mars' northern polar cap is thought to contain the Red Planet's largest supply of water ice. It's cut by a swirl of deep valleys, and the permanent cap of dust and ice is 1,100-kilometres across and up to three-kilometres deep.



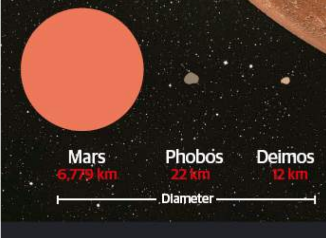
Phobos

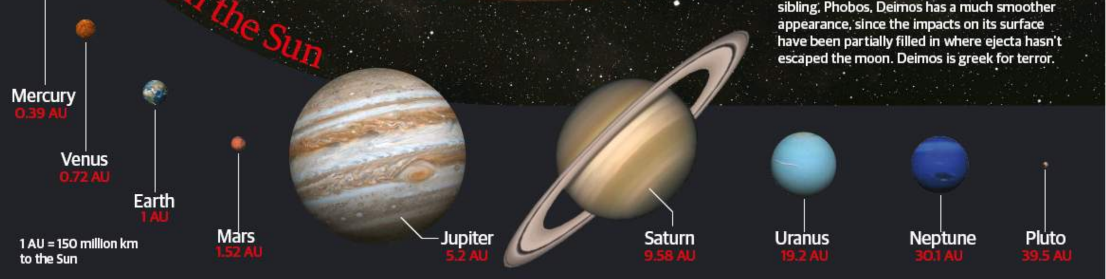
Phobos is the larger of Mars' two moons, and orbits the Red Planet three times a day. Its most distinguishing feature is a 9.7-kilometres (6-miles) Stickney crater, observed as a streaky pattern. Phobos is expected to crash into the Martian surface or shatter into a ring in roughly 50 million years. The name is derived from the Greek for fear.



Deimos

Much less irregular in shape than fellow sibling, Phobos, Deimos has a much smoother appearance, since the impacts on its surface have been partially filled in where ejecta hasn't escaped the moon. Deimos is greek for terror.





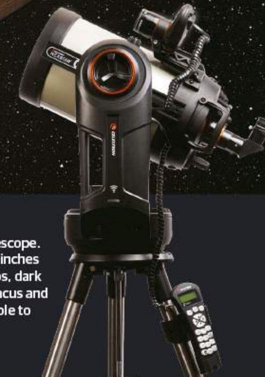
1 AU = 150 million km to the Sun

An unforgiving world

Mars is a very frigid world, where temperatures can drop to -225 degrees Fahrenheit. Its dust-storm ravaged surface is covered in rocks, canyons, inactive volcanoes, dry lake beds and craters. Its carbon dioxide atmosphere is thin, meaning Mars has no protection from radiation.

Observing the Martian surface

The Red Planet is best observed with a telescope. Instruments with apertures of at least four inches will reveal the planet's red colour, polar caps, dark regions – including Syrtis Major and Solis Lacus and by using a six inch aperture you'll also be able to see some Martian clouds and dust.



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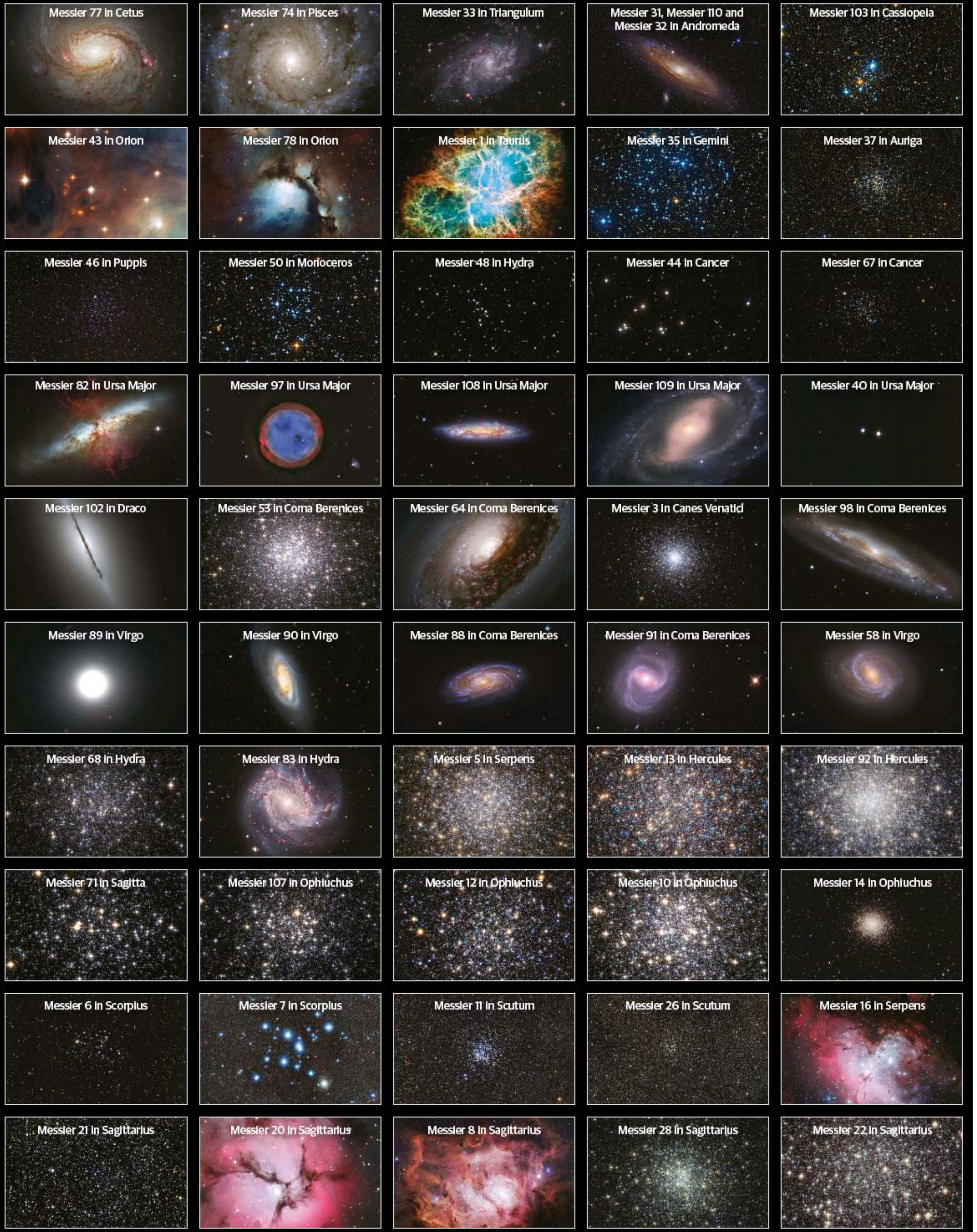

Messier Marathon

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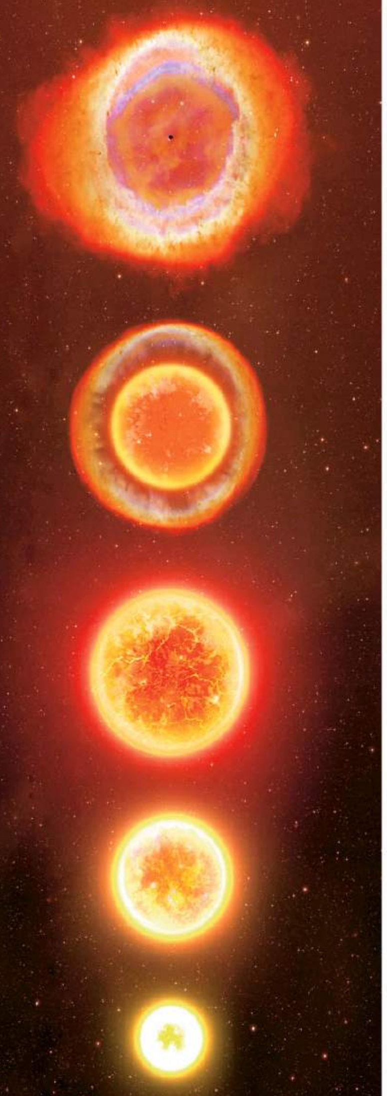

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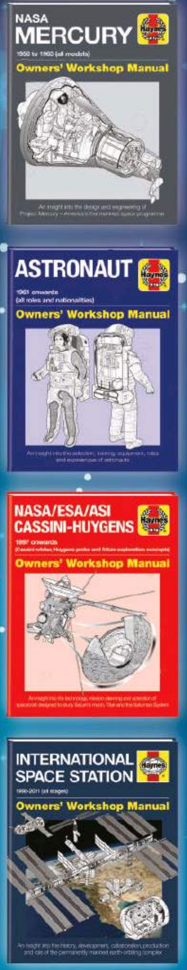
Haynes
A WORLD OF INFORMATION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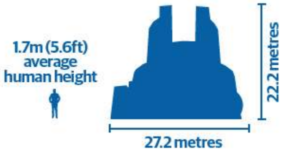
USER MANUAL

Subaru Telescope

This optical and infrared instrument has been operating since before the turn of the century, and it continues to provide valuable astronomical observations

THE SPECS

First light: January 1999
Primary mirror size: 8.2 metres (26.9 feet)
Primary mirror thickness: 20 centimetres (7.9 inches)
Location: Mauna Kea Observatory
Operator: National Astronomical Observatory of Japan (NAOJ)
Operational time: Around 19 years
Altitude: 4,139 metres (13,580 feet)



Sitting on top of the dormant volcano Mauna Kea in Hawaii, the Subaru Telescope takes advantage of one of the best astronomical observation sites on the planet. When the National Astronomical Observatory of Japan (NAOJ) commissioned the telescope back in 1991, they set out to build the best optical and infrared telescope possible, capable of discovering the secrets of the cosmos.

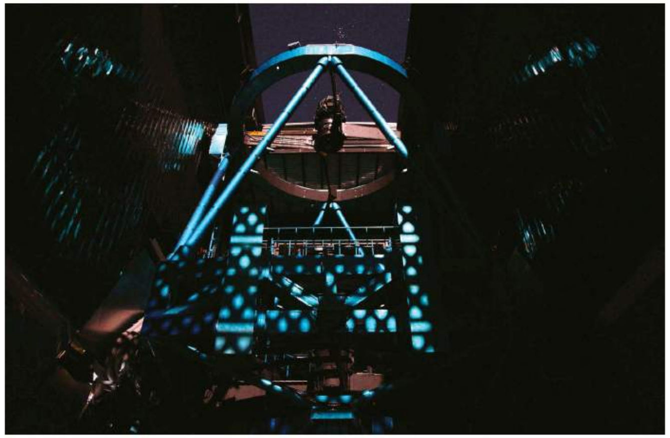
Although 'Subaru' may be a name commonly associated with automobiles, it originates from the Japanese name for the young cluster we know as Pleiades (Messier 45). Not only is it another name for 'The Seven Sisters' in the constellation of Taurus, but it also translates to 'tie together' from Japanese. This seems like a very befitting name for one of the world's most innovative telescopes, uniting the international astronomical community in their search for answers.

Construction began at the Mauna Kea site in June 1992 and wasn't fully completed until December 1998, starting scientific observations in January 1999. Some of the first light observations include the Orion Nebula (Messier 42), the spiral galaxy NGC 4051 and Abell 851. The construction process was a long and arduous journey. Engineers and scientists wanted to create the thinnest primary mirror possible, combine it with the latest technological advancements and enclose it in a state-of-the-art protective cylindrical dome, which helps to minimise air turbulence within the telescope's enclosure.

The product of such hard work and determination has brought us the sixth-largest optical reflector telescope, which is fitted with an impressive 8.2-metre (26.9-foot) single primary mirror within a Ritchey-Chrétien optics system. The mirror was carefully designed to provide the highest possible resolving power. This attention to detail results in an average surface error of just 0.012 micrometres - equivalent to about one in five thousandths of the thickness of a human hair.

There are four focal points to the Subaru Telescope. Each of these focal points has carefully-selected designated cameras and spectrographs to allow for the observation of the greatest range of cosmic events. The prime focus is situated at the tip of the telescope's 'nose', and this region has an impressive 870-megapixel, optical camera as well as a wide-field spectroscopy sytem able to image over 100 objects at once. Lower down towards the base

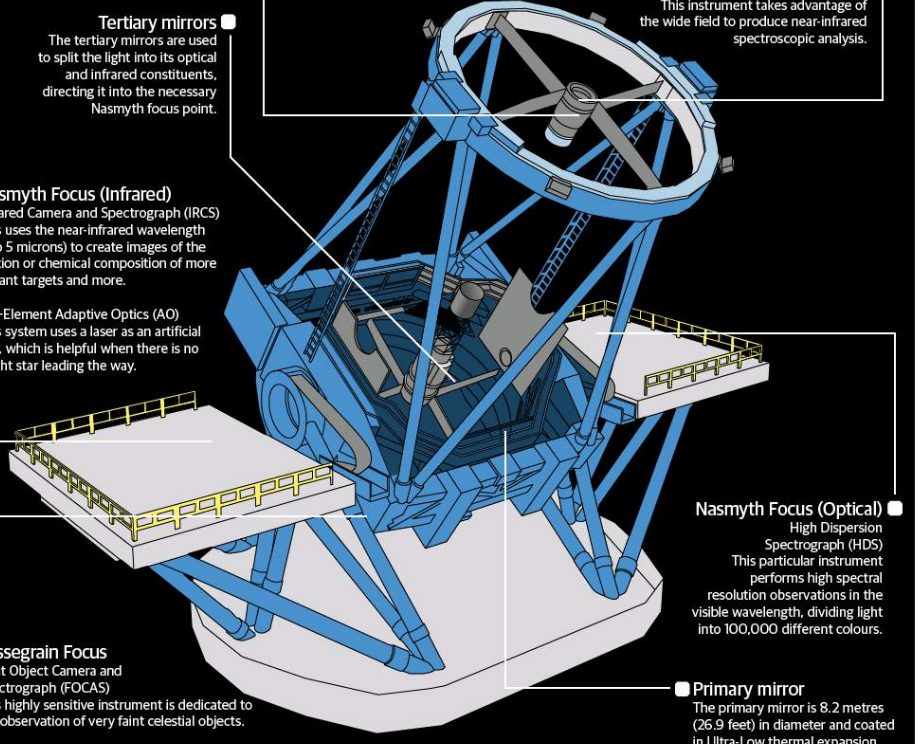
Pleiades (M45) and Jupiter glisten above the Subaru Telescope



The Subaru Telescope has a focal length of 15 metres (49.2 feet)

Anatomy of the Subaru Telescope

The observatory's nine cameras and spectrographs span a range of wavelengths, utilising all four focal points



Secondary Mirror
The secondary mirror is 1.3-metres (4.3 feet) in diameter and is used to redirect the collected light to the Nasmyth foci, without the need for coolant.

Prime Focus
Hyper Suprime-Cam (HSC)
This camera provides an ultra-wide field of view intended for measuring the distribution of dark matter.

Fiber Multi-Object Spectrograph (FMOS)
This instrument takes advantage of the wide field to produce near-infrared spectroscopic analysis.

Tertiary mirrors
The tertiary mirrors are used to split the light into its optical and infrared constituents, directing it into the necessary Nasmyth focus point.

Nasmyth Focus (Infrared)
Infrared Camera and Spectrograph (IRCS)
This uses the near-infrared wavelength (1 to 5 microns) to create images of the motion or chemical composition of more distant targets and more.

188-Element Adaptive Optics (AO)
This system uses a laser as an artificial star, which is helpful when there is no bright star leading the way.

Nasmyth Focus (Optical)
High Dispersion Spectrograph (HDS)
This particular instrument performs high spectral resolution observations in the visible wavelength, dividing light into 100,000 different colours.

Cassegrain Focus
Faint Object Camera and Spectrograph (FOCAS)
This highly sensitive instrument is dedicated to the observation of very faint celestial objects.

Multi-Object Infrared Camera and Spectrograph (MOIRCS)
Near-infrared, multi-object observations are handled by this instrument.

Cooled Mid-Infrared Camera and Spectrograph (COMICS)
This instrument handles the mid-infrared observations, which are between 7.5 and 25 microns.

Primary mirror
The primary mirror is 8.2 metres (26.9 feet) in diameter and coated in Ultra-Low thermal expansion glass, which is vital to gain the best possible observations.

> "This attention to detail results in an average surface error of just 0.012 micrometres"

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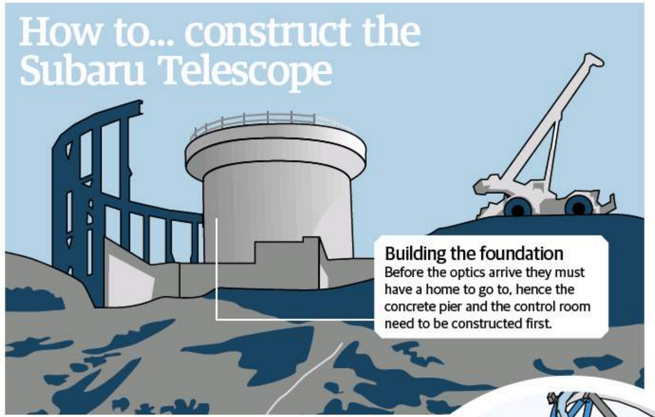
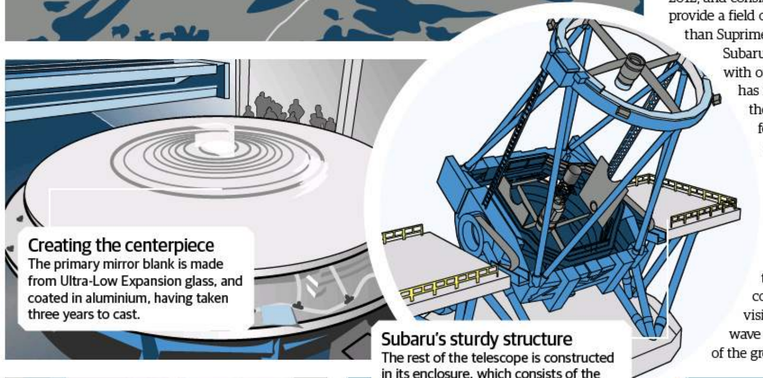
How to... construct the Subaru Telescope

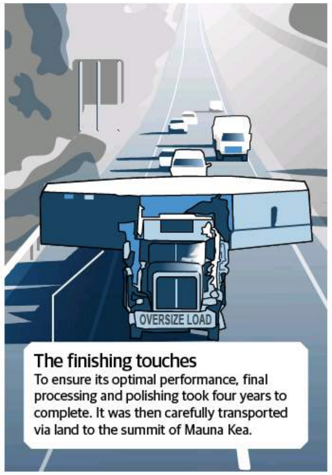


Building the foundation
Before the optics arrive they must have a home to go to, hence the concrete pier and the control room need to be constructed first.

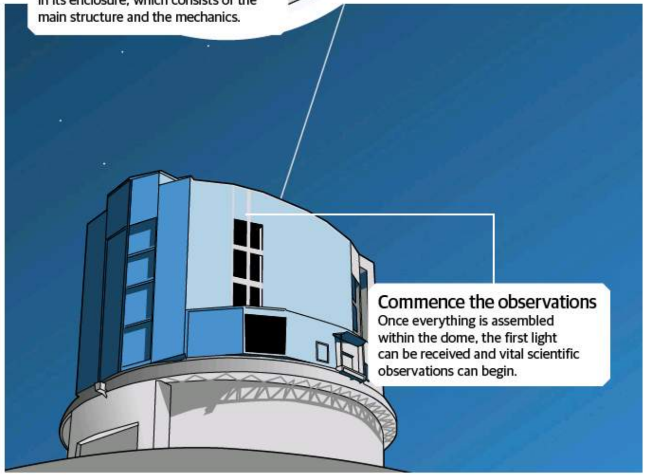


Creating the centerpiece
The primary mirror blank is made from Ultra-Low Expansion glass, and coated in aluminium, having taken three years to cast.

Subaru's sturdy structure
The rest of the telescope is constructed in its enclosure, which consists of the main structure and the mechanics.



The finishing touches
To ensure its optimal performance, final processing and polishing took four years to complete. It was then carefully transported via land to the summit of Mauna Kea.



Commence the observations
Once everything is assembled within the dome, the first light can be received and vital scientific observations can begin.

there are two Nasmyth foci on opposite ends of the telescope; one collects optical light and the other infrared. Underneath the telescope is the Cassegrain focus; this can have different instruments attached depending on the research goals. The three Cassegrain instruments - the Faint Object Camera and Spectrograph (FOCAS), the Multi-Object Infrared Camera and Spectrograph (MOIRCS) and the Cooled Mid-Infrared Camera and Spectrograph (COMICS). While the Sun is out, astronomers must plan which target they intend to observe and then determine which instruments are to be used. This is when engineers use the Cassegrain Instrument Automatic Exchanger (CIAX) to swap over these hefty pieces of Cassegrain apparatus in roughly two hours. The Top Unit Exchanger helps in the exchange of the secondary mirrors and the Hyper Suprime-Cam (HSC). The HSC replaced the original Subaru Prime Focus Camera (Suprime-Cam) in 2012, and consists of 116 highly sensitive CCDs to provide a field of view, which is seven-times wider than Suprime-Cam.

Subaru's uniqueness and collaborations with other worldwide organisations has meant the telescope has been at the heart of scientific discoveries for around 19 years. NAOJ was also involved in the follow-up observations of two merging neutron stars, which created the gravitational wave emission formally known as GW170817. The Subaru Telescope was one of the many telescopes that turned its top-tier optics to the constellation of Hydra to find the visible counterpart of the gravitational wave detection. This is only one example of the groundbreaking discoveries that Subaru has made or contributed to throughout the years. Subaru has not just focused on the depths of the universe though; it has also provided us with valuable images of objects within our Solar System. For example, Subaru's mid-infrared imaging, using COMICS, was used to aid NASA's Juno spacecraft, providing information about the temperature distribution of Jupiter.

The Subaru Telescope sits on the summit of the Mauna Kea volcano

NAOJ continues to maintain and improve the telescope to an incredibly high standard, establishing itself as one of the world's best ground-based optical telescopes. Not only does it have the finest optics, technologies and engineers dedicated to its maintenance, but its prime location on the Mauna Kea volcano provides astronomers with 240 clear nights per year. It's thanks to this why the Subaru Telescope has been, and remains to be, pivotal in the role of understanding the universe.

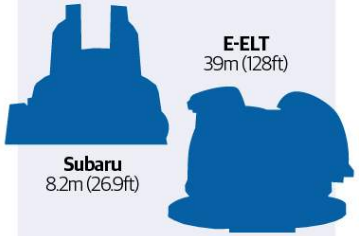
TOP TECH

Subaru's Hyper Suprime-Cam (HSC)

The Hyper Suprime-Cam is a much needed upgrade from the previous Subaru Prime Focus Camera (Suprime-Cam), with 106 more CCDs then its predecessor, totalling 116. 104 of these are main science CCDs, four are used for auto guiding and eight are for auto focusing. To keep the gigantic camera in an optimal condition, it is kept at a freezing -100 degrees Celsius (-148 degrees Fahrenheit). It is attached to the prime focus of the Subaru Telescope, and provides a more refined field of view of 1.5 degrees (diameter) of the night sky: equivalent of fitting nine full Moons within one of its images.

Head to head
Subaru vs E-ELT

The European Southern Observatory's European Extremely Large Telescope (E-ELT) will have an enormous 39-metre (128 feet) primary mirror, making the Subaru Telescope seem minuscule once completed. With first light planned for 2024, the E-ELT will be 'the world's biggest eye on the sky'. Both telescopes are, and will, observe the optical and infrared radiation of the universe, but the E-ELT will have a have a significantly higher resolving power as a result of its incredible design and technology, revolutionising our understanding of the cosmos. One thing's for sure, the E-ELT will truly be out of this world.



Vital statistics

8.2* *Metres The diameter of the primary mirror.	=	The length of two classic Mini Coopers.
4,139* *Metres The altitude of the Subaru Telescope.	=	This is almost half the way up Mount Everest.
555* *Tonnes Weight of the telescope structure.	=	The combined weight of over 150 white rhinoceroses.
7 Years The minimum time taken to construct the telescope.	=	Over 2,557 days, or 61,368 hours!
13 Number of telescopes at the Mauna Kea Observatory.	=	Observes optical, infrared and radio emission.

HOW TO... swap the Cassegrain instruments

1 Preparing for the night ahead

Before any decisions are made regarding which instrument is being added to the Cassegrain focus, the astronomers must do their research and determine which instrument is best suited for their observational needs.

2 Maneuvering with the CIAX

Each of the three Cassegrain instruments is enclosed in its own two-tonne cube. This is beyond the carrying capabilities of the telescope maintenance engineers, so the Cassegrain Instrument Auto Exchanger (CIAX) is deployed.

3 Communicating with the cart

There is no Wi-Fi system inside the dome, as it could affect the sensitive neighbouring radio telescopes. All communications between the cart and the telescope are done via a wire, which is attached to a fishing pole to help movement.

4 The successful swap

Once the engineers have successfully detached the original instrument, the CIAX transports it to the standby room. They then bring in the intended instrument for the night and carefully attach it.

©Adrian Mann; NAOJ.

SPACE TED TALKS

...YOU NEED TO WATCH

BE EVEN MORE INSPIRED BY THE UNIVERSE WITH **ALL ABOUT SPACE**'S TOP PICKS OF IDEAS WORTH SPREADING

Written by Libby Plummer

Why we need the explorers

Professor Brian Cox

The popular physicist explains the importance of investment in exploratory space programmes and curiosity-driven science.

Adventures of an asteroid hunter

Dr Carrie Nugent, astronomer at the California Institute for Technology (Caltech)

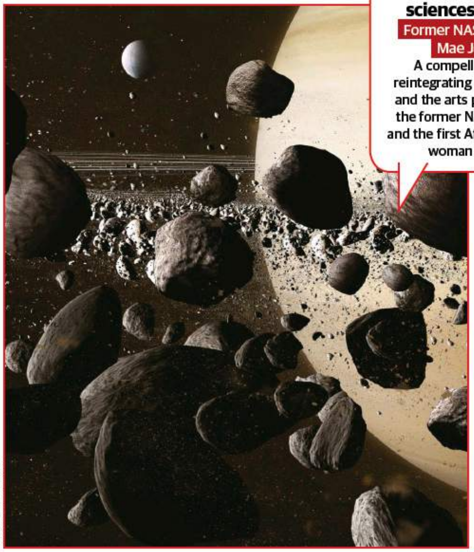
This enlightening talk centres on our oldest cosmic neighbours, asteroids, and their importance to us here on Earth. Not only can asteroids shed light on the beginnings of the Solar System, they also pose a massive risk to our safety. For example, in 2013 the Chelyabinsk asteroid entered the Earth's atmosphere over a remote area of Russia and created a shockwave that shattered windows, rocked buildings and caused hundreds of injuries. A similar incident, on a much larger scale, is thought to be related to the fate of the dinosaurs. As a result, near-Earth asteroids are now constantly monitored in order to try and prevent another catastrophic strike on Earth. Carrie Nugent is part of the team that uses NASA's NEOWISE telescope, a very valuable telescope that was pulled out of retirement and reprogrammed to search the skies for asteroids and catalogue them. In her talk, she reveals some breathtaking details about the size of the asteroid that wiped out the dinosaurs. She also explains what else is already being done to prevent another potentially deadly asteroid strike, and what needs to be done in future.

> "It has only been within my lifetime that asteroids have been considered a credible threat to our planet" **Dr Carrie Nugent**

Teach arts and sciences together

Former NASA astronaut Mae Jemison

A compelling case for reintegrating STEM subjects and the arts put forward by the former NASA astronaut and the first African-American woman in space.



© NASA; Tobias Roetsch

How to take a picture of a black hole

Dr Katie Bouman, imaging scientist at the Massachusetts Institute of Technology

How LIGO discovered gravitational waves – and what might be next

Professor Gabriela González

The Argentinian astrophysicist explains the Nobel Prize-winning confirmation of Einstein's prediction and what it means for our understanding of the universe.

So far, we've only been able to see what the inside of a black hole might look like thanks to computer graphic rendering, like those seen in the film *Interstellar*. Despite Einstein's prediction of black holes in his theory of general relativity more than 100 years ago, we still haven't been able to take a picture of one. But that could be about to change any day now, explains Katie Bouman in her fascinating TED Talk. A telescope capable of capturing images of a black hole would need to be as big as the Earth itself, making it impossible. However, Bouman is working as part of a team of international experts to produce a giant computational telescope - known as the Event Horizon Telescope - combining the power of telescopes around the world with imaging algorithms to fill in the gaps. In this talk, she reveals the extraordinary process of developing these algorithms based on what experts believe a black hole should look like, using pieces of images from everyday life in order to avoid bias. Viewers will get a glimpse at how astronomers, physicists, mathematicians and engineers have come together to solve a seemingly impossible quandary, pushing the boundaries of science.

> "Is it possible to see something that, by definition, is impossible to see?" **Dr Katie Bouman**

Your kids might live on Mars. Here's how they'll survive

Stephen Petranek, editor-in-chief of Breakthrough Technology Alert

Will we all be living on Mars in the near future? Award-winning journalist, Stephen Petranek, firmly believes it's not a question of if, but when. His future-gazing talk looks at how we might survive on the Red Planet, and makes some pretty bold predictions about when this might actually become a reality. As well as reviewing the reasons why humans need to make the long journey to Mars, he discusses the physical differences between the potential Earth 2.0 and our home planet, comparing the size, temperature, atmosphere and gravity. While acknowledging humankind's poor track record of successful unmanned missions to Mars, he sets out the challenges of making this trip, including surviving in such an inhospitable environment, as well as the contributions made by government agencies like NASA and private firms like SpaceX. From how we'll source enough oxygen and water to live on, to plans for terraforming the planet to make it more Earth-like, this is a comprehensive look at the future of Mars as a colony. It even raises the exciting possibility of a new human species evolving to adapt to the harsh conditions on the Red Planet.

I leapt from the stratosphere. Here's how I did it

Alan Eustace, computer scientist and former Senior Vice President of Knowledge at Google

Best known for breaking the world record for the highest-altitude free-fall jump set by Austrian daredevil Felix Baumgartner in 2012, Alan Eustace floated up into the stratosphere attached to a balloon in 2014, before plummeting back towards Earth and parachuting to safety. Eustace made it to over 135,000 feet in a custom-built space suit before starting his descent and parachuting the final 10,000 feet. In this talk, he explains how the mission came to be as he pondered whether the stratosphere - one of the least accessible places on (or above) Earth - could be explored. Eustace talks the audience through the life-preserving features of his stratospheric suit, which is made by the same company that produced the Apollo mission spacesuits. There's also a short video showing the preparation for the jump, as well as the death-defying feat itself. Largely a talk about the incredible engineering that makes these kind of accomplishments possible, he also talks us through the specially designed parachute technology that kept him from meeting a messy end after plummeting back to Earth.

ET is (probably) out there – get ready

Dr Seth Shostak of the SETI Institute

While we've yet to make contact with any other form of life beyond our own planet, Seth Shostak is so confident that we'll find ET in the coming years he bet everyone listening to his TED talk a cup of coffee if he's wrong. As a senior astronomer at SETI (Search for Extraterrestrial Intelligence), Shostak has been searching for signs of intelligent life in space for some time. His riveting, and at times hilarious, account of his work highlights the growing likelihood of finding aliens in the near future. Recent developments in equipment and missions, such as NASA's Kepler exoplanet-hunting mission, enables better estimations of known planets that might hold alien life, with the search speeding up exponentially. Not only does he explain how the search for cosmic company is progressing, he also ponders what success could mean, and how difficult it is to predict the consequences of an alien interaction. Focusing on the huge benefits of exploration, the talk looks at how making contact with alien civilisations more advanced than our own could help us here on Earth, while the search itself is helping to improve science literacy and encourage more children to pursue STEM subjects.

The untapped genius that could change science for the better

Astrophysicist Jedidah Isler

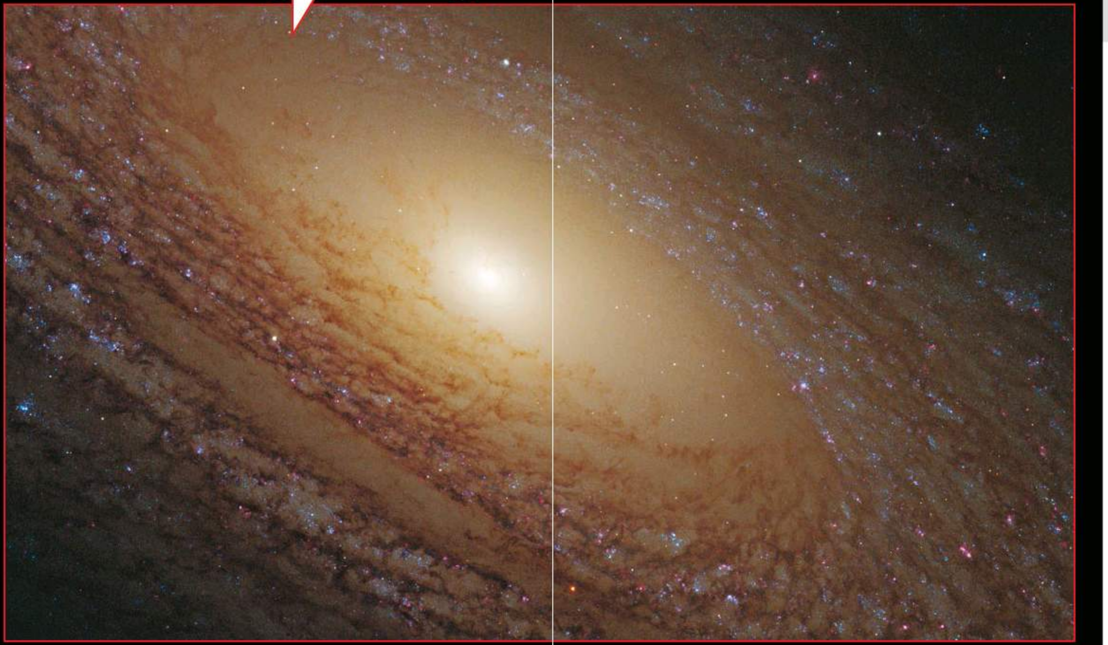
The first black woman to earn a PhD in astrophysics from Yale spells out the value of diversity and intersectionality in STEM and beyond.

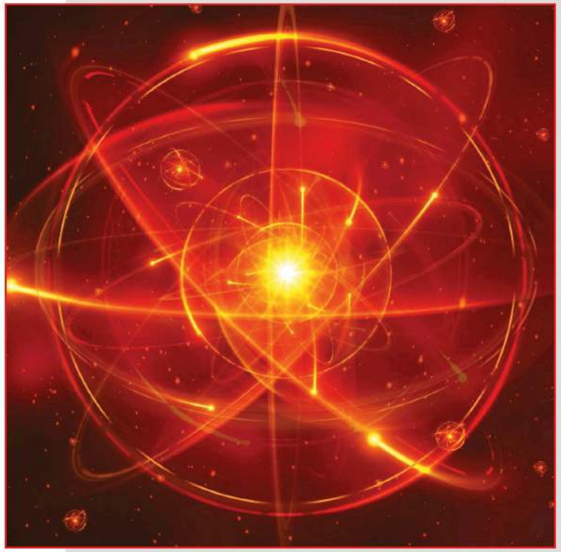
Is our universe the only universe?

Professor Brian Greene, professor of mathematics and physics, Columbia University

This action-packed talk explores the possibility that our universe is part of a vast complex of universes called the multiverse. The animated lecture is given by theoretical physicist Brian Greene, perhaps the best-known proponent of superstring theory, the idea that tiny strands of energy vibrating in a higher dimensional space-time create every single particle and force in the universe. He breaks down the complicated idea into three parts, starting with the idea that space is expanding, and how Nobel Prize-winning research in the 1990s discovered that rather than slowing down, this expansion rate is getting faster. The talk reveals how this is driven by mysterious 'dark energy', and explains how string theory fits in to all this. Touching on the possibility of additional dimensions in space that we have not yet detected because of their tiny scale, Greene ends on some startling revelations about what future astronomers will observe and conclude, based on the idea that other galaxies are rushing away from our own, and will eventually be too far away to see.

> "Astronomers in the far future looking out into deep space will see nothing but an endless stretch of static, inky, black stillness" **Professor Brian Greene**





Have we reached the end of physics?

Dr Harry Cliff, particle physicist at CERN and Science Museum Fellow of Modern Science

Particle physicist Harry Cliff takes us on a mind-boggling journey to discuss the future of physics. As a scientist working on the Large Hadron Collider at CERN, Cliff is well placed to run through the basics of Einstein's general theory of relativity and quantum mechanics, and how these groundbreaking ideas have completely transformed our understanding of the universe. Over 100 years on from Einstein's theory, physics is at another turning point, explains Cliff. Could the laws of physics prevent us from making further discoveries and stop us from every truly understanding why there is 'something rather than nothing'? CERN's discovery of the Higgs Boson may have proved the existence of a cosmic energy field, but the Higgs field is still not fully understood. What's more, the mysteries of dark energy, string theory and the concept of the multiverse are all compelling concepts, but Cliff questions whether we will ever be able to explain or definitively prove their existence. Are we entering a new world of science where the laws of physics have reached their limit and we're simply not capable of proving or disproving our theories?

> "We may be entering a new era in physics where there are weird features of the universe that we cannot explain" **Dr Harry Cliff**

How to go to space, without having to go to space

Angelo Vermeulen, crew commander for NASA

Belgian visual artist Angelo Vermeulen, who is also a crew commander of the NASA-funded HI-SEAS (Hawaii Space Exploration Analog and Simulation) Mars simulation, has already completed a four-month stay in the isolated dome on Hawaii's Mauna Loa Volcano. The idea is to prepare humans for life in deep space by investigating how crew members can successfully live together in such small and isolated places. While staying in the dome the team also carried out a number of research projects, including a food study and missions in mockup spacesuits. In his talk, Vermeulen also runs us through his art project called 'Seeker', which encourages teams around the world to come up with prototypes for long-duration mission starships. Along with other artists, Vermeulen runs isolation tests where he lives inside these art projects. He also talks about how the Atacama Desert in Chile is home to one of these projects. As the driest location on the planet, this location has also been used by NASA for training, as it's the closest thing we have to the arid geology of Mars. What's more, he hopes to use these insights on living in such an environment from the indigenous population and integrate these into space exploration technology in the future.

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Look up for a change

Lucianne Walkowicz, stellar astronomer on NASA's Kepler mission

The night sky provides an incredible view, but what if we're not able to see it? In this talk, Lucianne Walkowicz speaks about how light pollution is ruining our extraordinary view of space. While there is a tendency to believe that this loss is an inevitable result of technological progress, Walkowicz, who works on NASA's exoplanet-hunting Kepler mission, says that this need not be the case, and that the night sky should be treated as a natural resource that must be preserved. The intense light from urban settlements around the globe is so distinct it can be photographed from space. But, most of the energy used to light outdoor spaces is wasted, says Walkowicz, leaving plenty of room for improvement. She also explains how people can learn more about the night sky thanks to a range of 'citizen science projects'. These involve organisations sharing their data online and teaching people how to interact with it so they can make contributions to research. Some projects involve asking people to help classify photos from space, while new exoplanets were discovered by participants as part of the Kepler project.

> "I never saw a truly dark night sky until I was 15"
>
> **Lucianne Walkowicz**

What I learned from going blind in space

Former CSA & NASA astronaut Chris Hadfield

An incredible tale of how facing fears enables astronauts to deal with the dangers of spaceflight by the Space Oddity-singing Canadian astronaut.

The search for planets beyond our Solar System

Professor Sara Seager, astrophysicist at the Massachusetts Institute of Technology

Astrophysicist and planetary scientist Sara Seager's research led to the first discovery of an atmosphere on a planet outside our Solar System. In this inspiring talk, the exoplanet expert speaks about the search for potentially habitable worlds beyond our own. Thousands of exoplanets have been pinpointed during the last couple of decades, but that's just the tip of the iceberg. The astonishing variety of exoplanets already discovered includes gas giants that would be far too hot to support life, in contrast with Kepler-186f, so far considered to be one of the most likely spots for discovering life. This Earth 2.0 is a so-called 'Goldilocks' planet, not too hot or too cold, but just the right temperature. However, what's really important in the search for potentially habitable exoplanets is examining their atmospheres, explains Seager. While the Hubble Space Telescope has been used to study the atmospheres of larger exoplanets, we still don't have the technology to study smaller planets. This intriguing talk highlights the importance of assessing the amount of gases present in these distant worlds, and how that could lead to the discovery of intelligent alien life.

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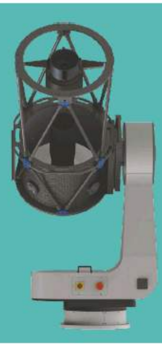
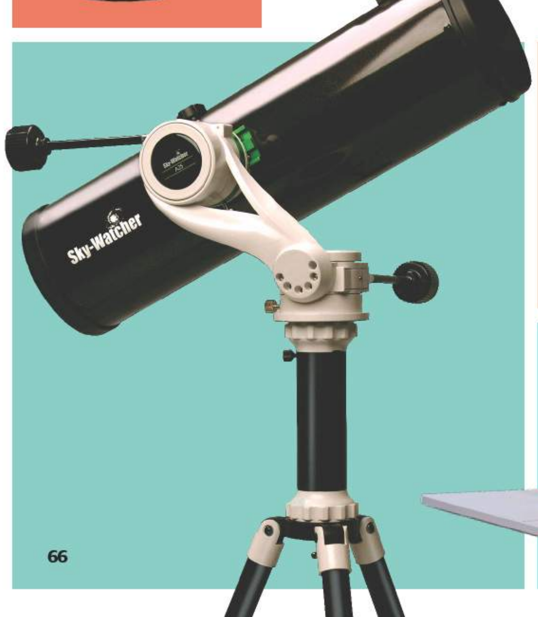


20 HOTTEST ASTRONOMY PRODUCTS FOR 2018



Solar Eclipse Timer

Local Time
08 : 45 : 44

Totality Duration
00 : 02 : 40

1st Contact 11:56:04 Adjust

2nd Contact 13:24:11 Adjust

Max Eclipse 13:25:31

3rd Contact 13:26:51 Adjust

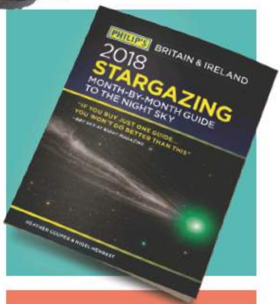
4th Contact 14:51:15 Adjust

Use Glasses For Eye Safety Partial Phases

Check Position

Save Eclipse Data

Looking for an upgrade for your telescope? Need a comprehensive guide for touring the night sky? Step this way...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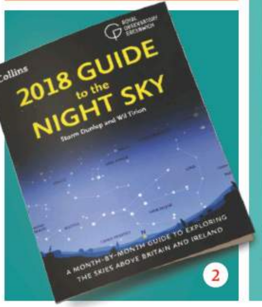
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ROYAL OBSERVATORY GREENWICH
2018 GUIDE to the NIGHT SKY
Storm Dunlop and Wil Tirion
A MONTH-BY-MONTH GUIDE TO EXPLORING THE SKIES ABOVE BRITAIN AND IRELAND
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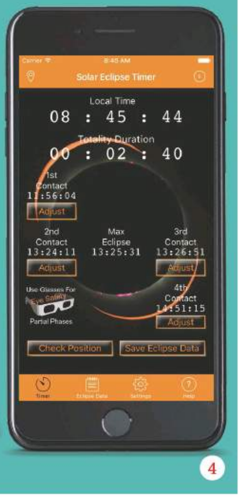


Telescope

StarNavigator NG 130mm Travel Pack

Cost: $469.00 (approx. £350.00)
From: Meade Instruments

1 Featuring an easy-to-operate, lightweight and portable robotic mount with Meade's AudioStar computer controller, the StarNavigator Series offers GoTo telescopes at a great price. With a flick of a switch and a brief alignment procedure, this computerised instrument is ready to take you on a guided tour of the night sky's best objects. AudioStar features a database of 30,000 objects and over four hours of audio presentations built in, so you can learn about the objects you're viewing. Includes a carrying bag, lightweight aluminium frame, advanced electronics, internal clock, external power connector, Vixen dovetail receiver and full height-adjustable aluminium tripod, allowing for comfortable viewing.

Reference

2018 Guide to the Night Sky:

A month-by-month guide to exploring the skies above Britain and Ireland

Cost: £6.99 From: Collins

2 If you're hunting for a comprehensive handbook to the planets, stars and constellations visible from the northern hemisphere, then look no further than the *2018 Guide to the Night Sky*, penned by observer Storm Dunlop and illustrated by Wil Tirion, the guide is approved by astronomers at the Royal Observatory Greenwich. An easy introduction to astronomy and a useful reference for seasoned stargazers, this handbook provides advice on where to start looking, easy-to-use star maps for each month and has details of objects and events you might see in 2018.

Mount

SkyGuider Pro Equatorial Tracker

Cost: $469 (approx £350)
From: iOptron

3 A complete, super-portable mount for wide-field astrophotography, the iOptron SkyGuider Pro Camera Mount Package is a compact single-axis for cameras, bearing a load of up to 11 pounds (5 kilograms), and has four tracking rates for nightscape or deep-sky astrophotography. The tracker is powered by an internal rechargeable battery, with a SkyGuider Pro package that features a removable counterweight shaft along with a counterweight which weighs in at 3.3 pounds that can also be replaced with an additional ball head for dual-camera operation.

App

Solar Eclipse Timer

Cost: £1.89 For: iOS & Android

4 If you got in on the action of 2017's Great American Eclipse, or even if you missed out and you're keen on imaging the next one, then you'll need the Solar Eclipse Timer app, which will help you to plan and practice a photo sequence simply by using your smartphone's GPS. Solar Eclipse Timer works by automatically calculating the exact duration of each major phase of the eclipse, providing spoken countdowns leading to the first, second, third and fourth contacts as well as alerts for when it's safe to remove eclipse glasses and when you can put them back on. Solar Eclipse Timer also includes announcements of interesting occurrences during the eclipse, including temperature changes, wildlife behaviour and where you need to look for shadow bands.

Telescope

Orion SkyQuest XT10 PLUS Dobsonian reflector

Cost: £647.99 From: Orion Telescopes & Binoculars

5 A new addition to Orion's popular line of deluxe upgraded Dobsonian reflector telescopes, the SkyQuest XT10 PLUS features a 10-inch aperture with an impressive light-gathering ability that picks out subtle details in faint galaxies, nebulae and other deep-sky objects. If you want to observe the Moon or the planets of the Solar System, then this Dobsonian will impress with stunningly bright, clear and detailed views of the Moon and planets. Supplied with the Orion SkyQuest XT10 PLUS is a wealth of accessories, including 2" 28mm and 1.25" 10mm eyepieces, a shorty 2x Barlow Lens, eyepiece rack, EZ Finder II reflex sight and the popular DeepMap 600 Folding Star Chart, all designed to create an unforgettable stargazing experience.

Astrophotography

iNova's New Modular CCD cameras

Cost: $629.00 (approx. £470.00)
From: iNova's Technologies

6 If you're looking for a CCD that can handle any form of astrophotography, then look no further than this smart-imaging system from iNova Technologies. Featuring a compact camera body that encases an internal CPU with an 8-core ARM processor, along with 2 gigabytes of RAM, the iNova New Modular CCD camera allows for planetary and deep-sky imaging without the need of a computer. What's more, it's available with a variety of low-noise Sony IMX CMOS sensors and can be upgraded with a host of additional options, including SSD disks, Micro SDHC cards and even a mini wireless keyboard.

Astrophotography

Orion SteadyPix Quick Smartphone Telescope Photo Adapter

Cost: £20.99 From: Orion Telescopes & Binoculars

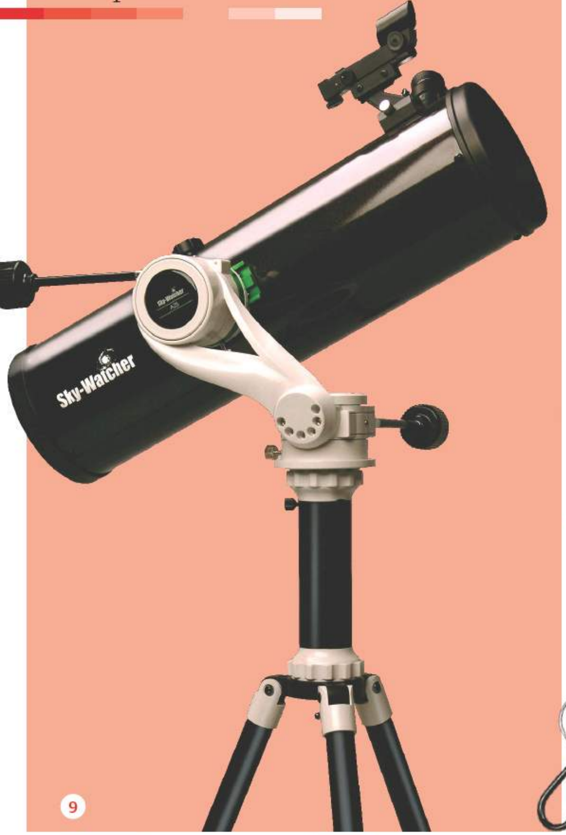
7 If you're not fully committed to purchasing a CCD or DSLR camera for astrophotography, then this adapter allows you to dip your toe into the world of astroimaging using just your smartphone. Featuring a quick and easy self-centering eyepiece clamp for quick installation, the SteadyPix provides a stable platform to yield clearly focused shots of the universe. Compatible with even the biggest modern smartphones, the Orion SteadyPix clamps to a versatile range of telescopes, binoculars and microscope eyepieces.

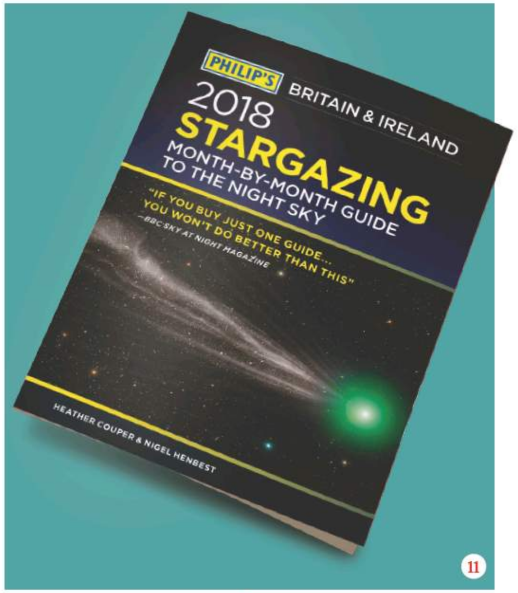
Solar telescope

Meade Coronado SolarMax III

Cost: $2,299 (approx. £1719.00)
From: Meade Instruments

8 Meade Instrument's latest generation of Coronado, its hydrogen-alpha solar scopes, is the new SolarMax III, which comprises of a 70mm refractor with a 2-inch dual-speed rack-and-pinion focuser, along with a 90-degree with a built-in blocking filter. Meade has released four new solar scopes in this range: models with a 0.7-angstrom bandpass have a single tuneable 60mm hydrogen-alpha filter mounted in front of the objective lens, while the 0.5-angstrom models posses a double-stacked filter set. Want a scope that's more versatile? No problem! Change the objective filter and substitute a standard diagonal and you can observe your favourite night-sky targets with no issues.

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TO THE NIGHT SKY
"IF YOU BUY JUST ONE GUIDE...
YOU WON'T DO BETTER THAN THIS"
—BBC SKY AT NIGHT MAGAZINE
HEATHER COUPER & NIGEL HENBEST
11

Telescope

Sky-Watcher Explorer-130PS

Cost: £249 From: Sky-Watcher

9 A grab-and-go telescope with a versatile dual-mode alt-azimuth/ equatorial mount, the Explorer-130PS is an all-rounder, suitable for observation of the Moon, bright planets, nebulae, galaxies and star clusters. Supplied with two flexible slow-motion cables that allow for smooth vertical and horizontal precise control, the Explorer-130PS also comes supplied with 10mm and 25mm eyepieces and an exceedingly useful red-dot finderscope.

Torch

Orion DualBeam Astro Lantern

Cost: $24.99 (approx. £18.70)
From: Orion Telescope & Binoculars

10 Make sure you're prepared for your observations with Orion's latest torch. It not only ensures that your night vision is protected, but also doubles up as a standard torch for 'non-astronomy' use. Waterproof and rechargeable thanks to a 2,600 mAH lithium battery, the Orion DualBeam Astro Lantern allows you to cycle through four brightness levels of red light, and two of white. Also included is a magnetic clip and a wrist strap that can charge your mobile device if you find you're running out of power during a night in the field.

Reference

Philip's 2018 Stargazing Month-by-Month Guide to the Night Sky (Britain & Ireland)

Cost: £6.99 From: Philip's

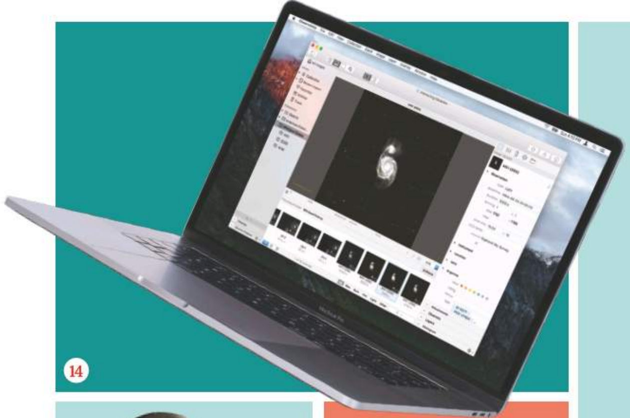
11 Written by astronomers Heather Couper and Nigel Henbest, *Philip's 2018 Stargazing Month-by-Month Guide* is packed with new features, which build on the previous editions of this handy guide. It includes a monthly calendar of Moon phases and special events throughout 2018, along with a dark sky map, revealing the best places to observe the night sky in the UK. It's also packed with a guide on buying binoculars and telescopes, and expert advice on what to catch every month.

Astronomy kit

Orion twist-lock star diagonals

Cost: From $119.99 (approx. £90.00)
From: Orion Telescopes & Binoculars

12 Eyepieces and camera adapters are locked into the red rings of these 90-degree mirror star diagonals with a simple twist, ensuring that you're observing the skies in no time. Orion's star diagonals feature dielectric coatings for roughly 99 per cent reflectivity and, for maximum versatility, are available in 1.25-inch and 2-inch sizes. The nosepieces of each are threaded to enable filters to be screwed in, while incorporated machine baffles reduce light scatter.



Astronomy kit

Starlight Instruments Feather Touch Micro-focuser

Cost: $249.00 (approx. £187.00)
From: Starlight Instruments

13 Get excellent precision with the 1.25-inch Feather Touch focusers from Starlight Instruments, which offer both a single-speed drive and a 10:1 dual speed for immediate improvements in bringing objects into focus in the field of view. Both have 3/4-inch of travel along with an 8-pound load capacity, travel brake as well as a draw tube with T-threads that allows for easy attachment to cameras and other accessories.

Software

Observatory

Cost: $79.95 (approx. £60.00)
From: Code Obsession

14 An image management and processing software for those using Mac computers, Observatory helps you to organise, process and analyse professional astronomical images, as well as the data you collect during your own observations. Observatory also allows you to search and import raw professional data from NASA and ESO for research or to process yourself, and supports FITS, SBIG, TIFF, JPG, PNG or RAW format images.

Astrophotography

Meade 70mm astrograph

Cost: $1,199 (approx. £899.00)
From: Meade Instruments

15 If you love nothing more than partaking in wide-field astrophotography with a DSLR, then the 70mm astrograph, which incorporates ED-glass lenses in a four-element Petzval design, is the perfect instrument for you. Its 42mm imaging circle covers a full-frame DSLR with a field of view that's more than 5.75-degrees wide. Features a 2.5-inch 10:1 dual focuser, a Vixen-style dovetail and tube rings.

Mount

PlaneWave L-500 Direct Drive Mount

Cost: $18,000 (approx. £13,485)
From: PlaneWave

16 Capable of operating in either alt-azimuth or equatorial modes, PlaneWave's new L-500 Direct Drive Mount loads telescopes of up to 200 pounds. Having a single-arm design with dovetail connections on both axes, this one-arm mount is able to take a whole host of loads regardless of their shape and size. What's more, the L-500 Direct Drive Mount allows for precise pointing with slewing speeds up to 50-degrees per second.

> "Observatory also allows you to search and import raw professional data from NASA"

18

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17

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Mobile imaging

ZWO ASIcap app

Cost: Free
From: Sony Semiconductor

17 ZWO's ASIcap does the job of desktop and laptop computers - it's able to take and store videos and images of the night sky and actually operates ZWO ASI USB 3.0 cameras. Fully operational only on Android devices, ASIcap lightens the load for astronomers who choose to travel to dark sky sites, without the need to lug a computer around.

> “ASIcap lightens the load for astronomers who choose to travel to dark sky sites”

Camera tracker

Sky-Watcher Star Adventurer Mini

Cost: $299.00 (approx. £225.00)
From: Sky-Watcher

18 Made just for astroimaging, the Star Adventurer Mini (SAM) allows you to track the sky for long exposures and offers motion control and panning for a whole range of capabilities. For a modest price, the Star Adventurer Mini stands out from the crowd, and can be used by beginner and advanced astronomers.

Binoculars

Astro-Physics premium binoculars

Cost: $460.00 (approx. £344.99)
From: Astro-Physics

19 A name that not many are familiar with - but don't let that put you off. Astro-Physics manufacture fantastic optics and these premium binoculars are no exception. Supplied with magnifications of 11x70 and 16x70, the optics offer a flatter field compared to conventional binoculars, along with reduced colour fringing. They also offer individual-focus eyepieces as well as full-illumination BaK4 porro prisms.

Telescope

Sky-Watcher Stargate Dobsonian

Cost: From $5,999 (approx. £4,489)
From: Sky-Watcher

20 Chase faint fuzzies with Sky-Watcher's latest offering - the Stargate Dobsonian. Released with apertures of 18 and 20-inches, these telescopes also offer a whole host of standard features, including lightweight mirrors capable of acclimating to changes in temperatures, as well as the option to attach a motor drive with GoTo, all for a cost that's significantly lower than similar scopes.

Planet Earth Education

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- The Moon causes eclipses whilst its phasing determines the date for Easter Sunday.
- Constellations can be used for navigation.
- Astronomy is one of the oldest sciences.

Planet Earth Education is one of the UK's most popular and longest serving providers of distance learning Astronomy courses. We pride ourselves on being accessible and flexible, offering attractively priced courses of the highest standards. Students may choose from five separate Astronomy courses, suitable for complete beginner through to GCSE and first-year university standard.

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All About Space

STARGAZER

YOUR ESSENTIAL GUIDE TO THE NIGHT SKY

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What's in the sky?

Jargon buster

Conjunction

A conjunction is an alignment of objects at the same celestial longitude. The conjunction of the Moon and the planets is determined with reference to the Sun. A planet is in conjunction with the Sun when it and Earth are aligned on opposite sides of the Sun.

Right Ascension (RA)

Right Ascension is to the sky what longitude is to the surface of the Earth, corresponding to east and west directions. It is measured in hours, minutes and seconds since, as the Earth rotates on its axis, we see different parts of the sky throughout the night.

Declination (Dec)

This tells you how high an object will rise in the sky. Like Earth's latitude, Dec measures north and south. It's measured in degrees, arcminutes and arcseconds. There are 60 arcseconds in an arcminute and there are 60 arcminutes in a degree.

Magnitude

An object's magnitude tells you how bright it appears from Earth. In astronomy, magnitudes are represented on a numbered scale. The lower the number, the brighter the object. So, a magnitude of -1 is brighter than an object with a magnitude of +2.

Opposition

When a celestial body is in line with the Earth and Sun. During opposition, an object is visible for the whole night, rising at sunset and setting at sunrise. At this point in its orbit, the celestial object is closest to Earth, making it appear bigger and brighter.

Greatest elongation

When the inner planets, Mercury and Venus, are at their maximum distance from the Sun. During greatest elongation, the inner planets can be observed as evening stars at greatest eastern elongations and as morning stars during western elongations.

Red light friendly
In order to preserve your night vision, you should read our observing guide under red light

7 JAN 👁
Jupiter and Mars make a close approach, passing within 0°12' of each other

©ESO

7 JAN 👁
Conjunction between Jupiter and Mars in Libra

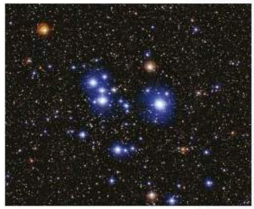
8 JAN 🔭★★
Conjunction between the Moon and dwarf planet Makemake in Virgo and Coma Berenices

10 JAN 🔭★★
Conjunction between the Moon and dwarf planet Haumea in Virgo and Boötes

11 JAN 👁
The Moon and Mars will make a close approach, passing within 4°23' of each other in Libra

11 JAN 👁
The Moon and Jupiter will make a close approach, passing within 4°09' of each other in Libra

14 JAN ∞
Open cluster M47 in Puppis is well placed for observation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14 JAN 🔭★★
Spiral galaxy NGC 2403 in Camelopardalis is well placed for observation

23 JAN 🔭★★★
Comet 74P/Smirnova-Chernykh is visible in the morning sky, glowing at magnitude 12.7 in Virgo

24 JAN 🔭★★
Conjunction between the Moon and dwarf planet Eris in Pisces and Cetus

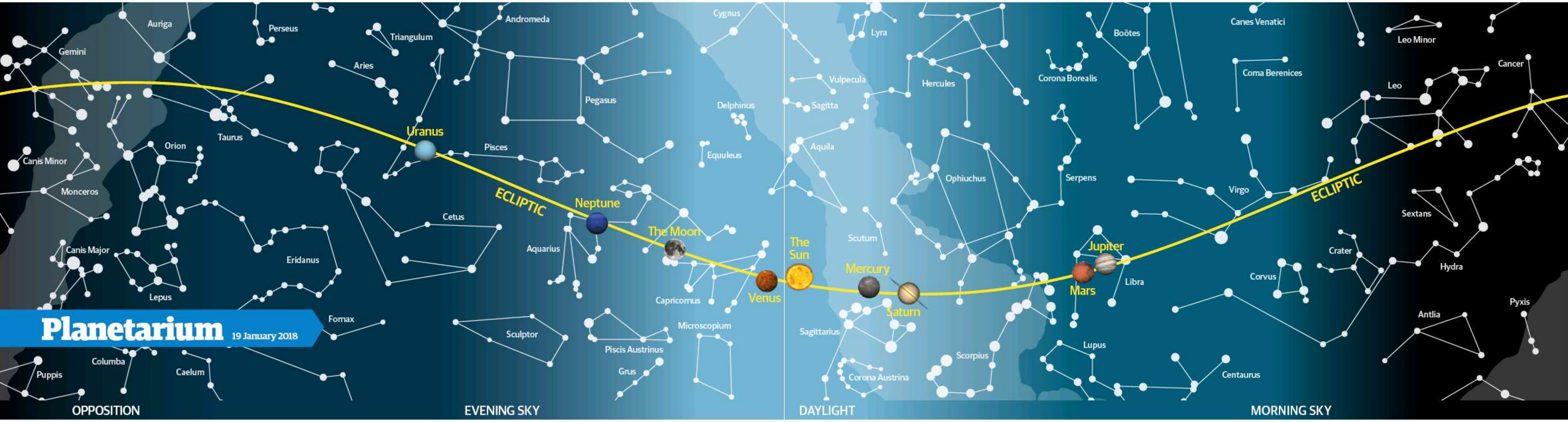
30 JAN ∞
Open cluster M44 in Cancer is well placed for observation

31 JAN ∞
Close approach between the Moon and M44, passing within 2°14' of each other in Cancer

31 JAN 🔭★★★
Dwarf planet Ceres is well placed for observation

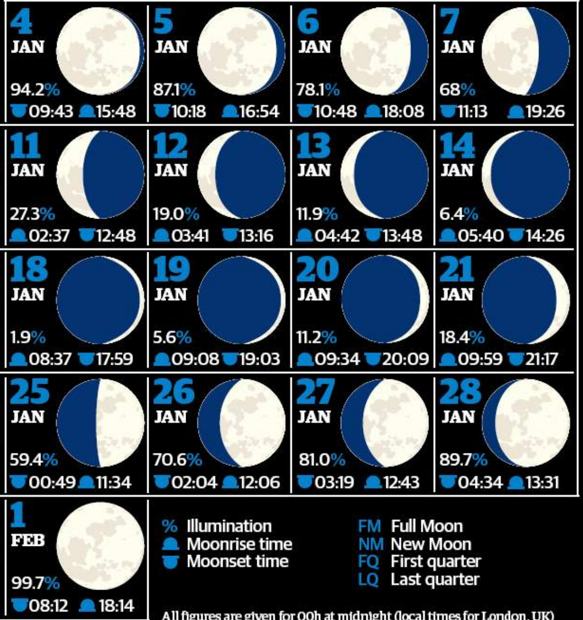
👁 Naked eye
∞ Binoculars
🔭★ Small telescope
🔭★★ Medium telescope
🔭★★★ Large telescope

Planetarium 19 January 2018



Moon calendar

* The Moon does not pass meridian on 31 January



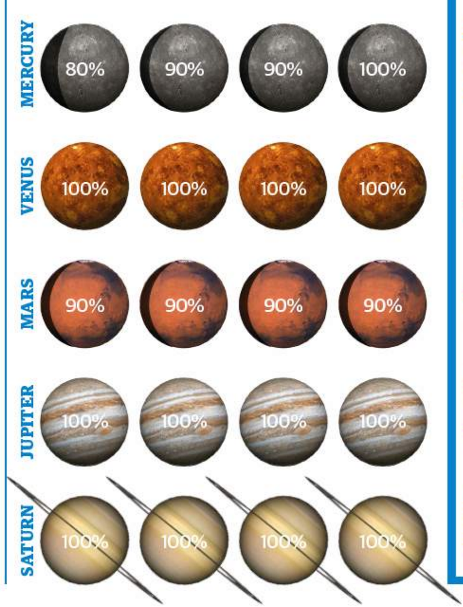
4 JAN		94.2%	▼09:43 ▲15:48
5 JAN		87.1%	▼10:18 ▲16:54
6 JAN		78.1%	▼10:48 ▲18:08
7 JAN		68%	▼11:13 ▲19:26
8 JAN	LQ	57.4%	▼11:36 ▲20:44
9 JAN		46.8%	▲00:23 ▼11:59
10 JAN		36.7%	▲01:31 ▼12:22
11 JAN		27.3%	▲02:37 ▼12:48
12 JAN		19.0%	▲03:41 ▼13:16
13 JAN		11.9%	▲04:42 ▼13:48
14 JAN		6.4%	▲05:40 ▼14:26
15 JAN		2.5%	▲06:34 ▼15:11
16 JAN		0.4%	▲07:21 ▼16:02
17 JAN	NM	0.2%	▲08:02 ▼16:58
18 JAN		1.9%	▲08:37 ▼17:59
19 JAN		5.6%	▲09:08 ▼19:03
20 JAN		11.2%	▲09:34 ▼20:09
21 JAN		18.4%	▲09:59 ▼21:17
22 JAN		27.2%	▲10:21 ▼22:26
23 JAN		37.2%	▲10:44 ▼23:36
24 JAN	FQ	48.1%	▲11:08 ▼-
25 JAN		59.4%	▼00:49 ▲11:34
26 JAN		70.6%	▼02:04 ▲12:06
27 JAN		81.0%	▼03:19 ▲12:43
28 JAN		89.7%	▼04:34 ▲13:31
29 JAN		96.1%	▼05:42 ▲14:29
30 JAN		99.5%	▼06:42 ▲15:38
31 JAN	FM	99.7%	▼07:32 ▲16:55
1 FEB		99.7%	▼08:12 ▲18:14

% Illumination
▲ Moonrise time
▼ Moonset time

FM Full Moon
NM New Moon
FQ First quarter
LQ Last quarter

All figures are given for 00h at midnight (local times for London, UK)

Illumination percentage



	12 JAN	19 JAN	26 JAN	1 FEB
MERCURY	80%	90%	90%	100%
VENUS	100%	100%	100%	100%
MARS	90%	90%	90%	90%
JUPITER	100%	100%	100%	100%
SATURN	100%	100%	100%	100%

Planet positions

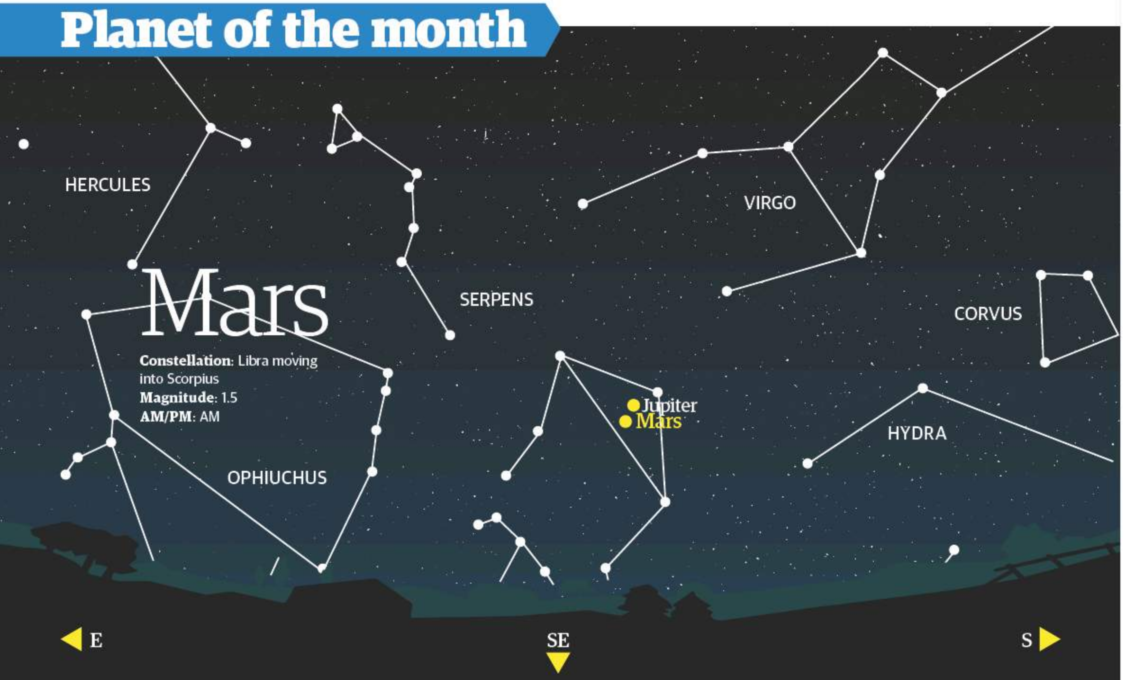
All rise and set times are given in GMT

	Date	RA	Dec	Constellation	Mag	Rise	Set
MERCURY	4 Jan	17h 20m 34s	-23° 33' 01"	Ophiuchus	-0.3	06:19	14:30
	12 Jan	18h 03m 31s	-23°00'54"	Sagittarius	-0.3	06:41	14:32
	19 Jan	18h 46m 25s	-23°29'51"	Sagittarius	-0.3	06:59	14:43
	26 Jan	19h 31m 57s	-23° 00' 20"	Sagittarius	-0.4	07:14	15:05
	1 Feb	20h 12m 10s	-21° 43' 30"	Capricornus	-0.6	07:21	15:30
VENUS	4 Jan	18h 52m 40s	-23° 28' 12"	Sagittarius	-3.9	08:04	15:49
	12 Jan	19h 36m 11s	-22° 28' 00"	Capricornus	-3.9	08:09	16:08
	19 Jan	20h 13m 34s	-20° 59' 21"	Capricornus	-3.9	08:09	16:27
	26 Jan	20h 50m 03s	-19° 00' 12"	Capricornus	-3.9	08:05	16:49
	1 Feb	21h 20m 31s	-16° 56' 37"	Capricornus	-3.9	08:00	17:08
MARS	4 Jan	14h 54m 22	-15° 43' 25"	Libra	1.5	03:18	12:40
	12 Jan	15h 14m 15s	-17° 09' 03"	Libra	1.4	03:14	12:20
	19 Jan	15h 31m 49s	-18° 17' 47"	Libra	1.3	03:11	12:03
	26 Jan	15h 46m 59s	-19° 20' 17"	Libra	1.2	03:08	11:47
	1 Feb	16h 04m 47s	-20° 08' 38"	Scorpius	1.2	03:04	11:33
JUPITER	4 Jan	15h 00m 08s	-15° 57' 11"	Libra	-1.8	03:25	12:44
	12 Jan	15h 05m 10s	-16° 17' 16"	Libra	-1.9	03:00	12:16
	19 Jan	15h 09m 11s	-16° 32' 45"	Libra	-1.9	02:38	11:51
	26 Jan	15h 12m 47s	-16° 46' 11"	Libra	-2.0	02:16	11:26
	1 Feb	15h 15m 30s	-16° 56' 01"	Libra	-2.0	01:56	11:04
SATURN	4 Jan	18h 06m 29s	-22° 32' 03"	Sagittarius	0.5	07:12	15:09
	12 Jan	18h 10m 28s	-22° 31' 36"	Sagittarius	0.5	06:44	14:42
	19 Jan	18h 13m 53s	-22° 30' 51"	Sagittarius	0.5	06:20	14:18
	26 Jan	18h 17m 09s	-22° 29' 49"	Sagittarius	0.5	05:56	13:54
	1 Feb	18h 19m 52s	-22° 28' 44"	Sagittarius	0.5	05:34	13:33

This month's planets

The Red Planet is an impressive sight for observers in the early hours, particularly as it meets Jupiter for a must-see conjunction

Planet of the month



Mars

Constellation: Libra moving into Scorpius
Magnitude: 1.5
AM/PM: AM

05:30 GMT on 7 January

As 2018 gets into its stride, things are really starting to improve for Mars observers. January sees the famous Red Planet shining in the pre-dawn sky like an orange-red star, brightening steadily. At the start of the month it will shine at magnitude 1.5, but by month's end it will have brightened to a very respectable 1.3, making it clearly visible to the naked eye, even from a light-polluted back garden.

This is a very interesting time for Mars enthusiasts. For a long time it has seemed inevitable that the next destination for astronauts would be the Red Planet, a dusty world of towering volcanoes, deep valleys and rock-strewn deserts. For the past two decades, every new robotic mission sent by NASA or ESA was seen as a stepping stone towards the goal of landing men and women on Mars.

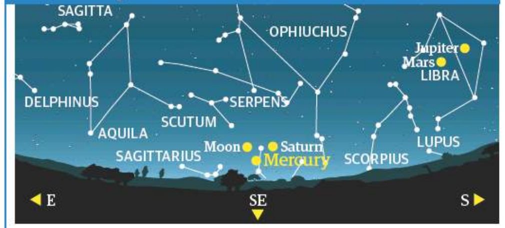
Elon Musk, of SpaceX, has made no secret of his desire to not just land on Mars, but to settle it, with fleets of spacecraft carrying hundreds of colonists to build homes on its dusty surface. More recently, however, the Trump administration has been urging NASA to turn its eyes back towards the Moon. There is now a lot of enthusiasm for sending astronaut crews to our satellite to build a base there, where they would learn how to live off-Earth before setting off for Mars.

Meanwhile, orbiters from several different countries continue to explore and map the surface of Mars, and two US rovers continue to trundle across it, studying its rust-coloured rocks and fascinating geological landscapes and sending back hundreds of new images every day.

As the month begins, Mars is rising almost five hours before the Sun, giving observers plenty of viewing time. Although its disc will be very small through an eyepiece - it will be much brighter and larger in a telescope eyepiece in summer - a high-power eyepiece could resolve tantalising hints of its shining white ice caps and dark deserts.

During the first week and a half of the month, Mars will appear to move towards, and then pass, much brighter Jupiter. The two worlds will be at their closest on the morning of 7 January, when they will be just 13 arc minutes apart, or less than a quarter of the diameter of the Moon in the sky. Between 10 and 12 January, the waning crescent Moon passes Mars and Jupiter, making for a very attractive celestial group photo in the pre-dawn sky.

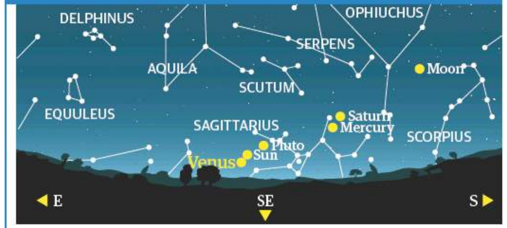
Mercury 07:30 GMT on 15 January



Constellation: Ophiuchus
Magnitude: -0.3
AM/PM: AM

An interesting month for Mercury observers, but by month's end it will be too close to the Sun to see. Watch out for its close encounter with Mars between 12 and 15 January, when the two worlds will slide past each other. Closest on the morning of 13 January, just half a degree apart, they will offer observers a lovely sight in binoculars.

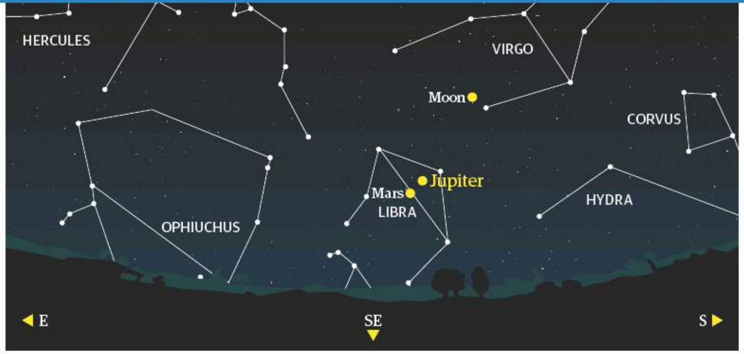
Venus 08:45 GMT on 13 January



Constellation: Capricornus
Magnitude: -3.9
AM/PM: PM

Don't let that very impressive magnitude value fool you - this will be a dreadful month for Venus observers. For most of this month it will just be too close to the Sun to be seen. As soon as the Sun has safely set you could try sweeping the sky just above the south-western horizon; but you will need luck on your side.

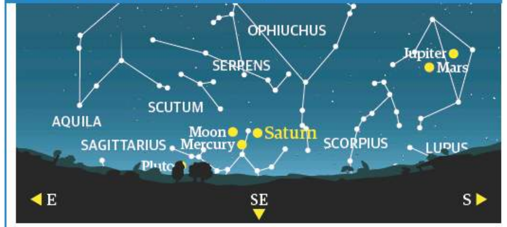
Jupiter 05:15 GMT on 10 January



Constellation: Libra
Magnitude: -1.9
AM/PM: AM

Jupiter is still dominating the morning sky at magnitude -1.9, making it much brighter than any of the stars in the sky, and currently any other planet on view, too. By the end of January Jupiter will be rising a good four hours before the Sun, so if you have a telescope you'll be able to observe Jupiter through it for hours, watching its colourful storms and cloud systems. Between 4 and 10 January, Jupiter will be passed by Mars. They will be at their closest on the morning of 7 January, when they'll be less than a third of a degree apart and will look like a very pretty 'double star' in the south east before dawn.

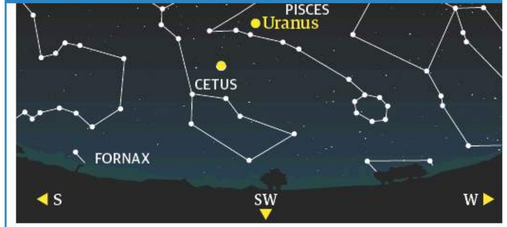
Saturn 08:00 GMT on 15 January



Constellation: Sagittarius
Magnitude: 0.5
AM/PM: AM

At the start of the month the famous ringed planet will be shining low in the south east before dawn, rising just an hour before the Sun. By month's end Saturn's visibility has improved, and it will be rising almost two hours before the Sun. Smaller and fainter Mercury will approach and then pass Saturn between 12 and 15 January.

Uranus 20:00 GMT on 15 January



Constellation: Pisces
Magnitude: 5.8
AM/PM: PM

This month Uranus will be on view from sunset until the early hours of the morning, glowing softly among the stars of Pisces. It will be much easier to track it down using binoculars or a small telescope. On the evening of 23 January, the Moon will lie six degrees to Uranus' lower left, which will help you find it.

© LFI

Top tip!

If you look at Mare Serenitatis when it is close to the terminator you will see more detail and surface relief to it.

Moon tour

Mare Serenitatis

When the Moon is full, enjoy views of one of the lunar surface's ancient lava seas

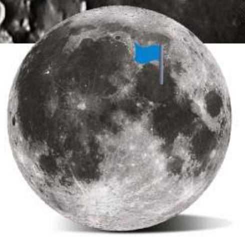
Look at the full Moon with your naked eye or a pair of binoculars on a frosty winter's night and you will see areas of light and dark. The light areas are known as the 'lunar highlands' and they are the oldest landscapes on the Moon, regions of mountainous, rugged terrain. The dark areas are the lunar 'seas', much younger than the ancient highlands. However, these seas are not like the huge stretches of water found on Earth. Instead, they are enormous plains of ancient, frozen lava.

At full Moon you will be able to see this month's Moon Tour target, Mare Serenitatis – the Sea of Serenity. Mare Serenitatis was formed around 3.8 to 3.9 billion years ago, when the Moon was experiencing a period of intense and heavy bombardment. As the Moon, still young itself, was being pummeled by countless planetesimals, asteroids and chunks of space debris left tumbling around the infant Sun after the birth of our Solar System, an enormous, Moon-shuddering strike blasted a huge impact basin out of the lunar surface. This basin then filled with lava that sloshed over its floor, covering it and any features on it.

Today we know that vast lava plain as Mare Serenitatis, one of the most obvious features on the Moon's surface. We also know that Serenitatis is approximately 674 kilometres (419 miles) across at its widest point, and more than 2 kilometres (6,500 feet) deep at its deepest point. Although the sea itself is very flat and smooth, its surroundings are not. Its western edge is marked by the jagged crater-pocked Appenninus and Caucusus Mountains, and more tortured, broken terrain lies on its southern border.

Although no crewed or uncrewed spacecraft have landed on the vast plain itself, in 1972 the final Apollo mission, Apollo 17, touched down on its south-eastern border, near the Taurus-Littrow Valley. The lunar module Challenger carried astronauts Eugene Cernan and Harrison H. Schmitt down to the surface, where they drove a lunar rover for almost 40 kilometres (25 miles), visiting different sites and collecting a wide variety of rocks. A year later the Russian Luna 21 robot probe, carrying the Lunokhod 2 rover, touched down in the same area.

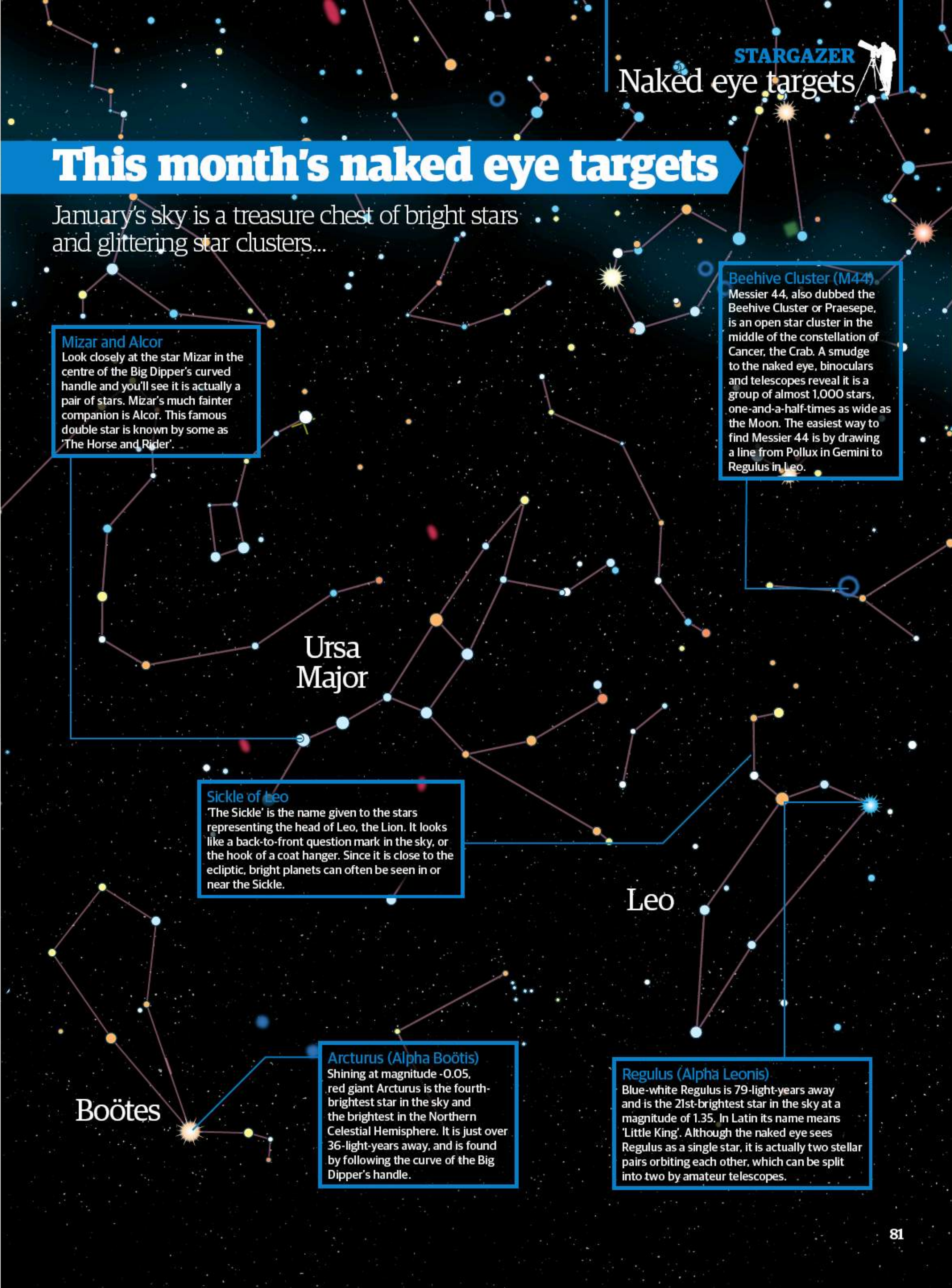
Looking at Mare Serenitatis through a small telescope, you immediately notice two features upon it. First, a small, round crater just below its centre. This is 16-kilometre (10-mile) wide Bessel. Looking at it, you'll notice the second feature – the crater sits in the centre of a bright 'ray' that looks like a white chalk line, pointing down towards the 27-kilometre (18-mile) wide crater Menelaus on the south 'shore' of the sea. This is the 'Bessel Ray', thought to be a splash of material from the impact that blasted the crater Tycho thousands of kilometres away to the south. Scanning Serenitatis through a telescope's high-power eyepiece will reveal it is marked with many wrinkles, ridges and crags, including a long, meandering ridge which runs from north to south on the sea's eastern side. There are also around a dozen other craters scattered across it, but they are all small and of no real significance.



When can you see this feature? As the month begins the Moon is almost full, leaving it in view until 6 January when the terminator – the line between night and day – begins to slide across it. On the evening of 7 January, the sea will only be half-visible, and by the 9 January will have been completely swallowed up by the relentlessly increasing shadow. It will remain hidden from view until the morning of 21 January, when the terminator's advance across the Moon allows sunlight to bathe the sea's shore again. By 23 January, the whole of Serenitatis is on view again as the waxing Moon hangs low in the western sky after sunset.

This month's naked eye targets

January's sky is a treasure chest of bright stars and glittering star clusters...



Mizar and Alcor

Look closely at the star Mizar in the centre of the Big Dipper's curved handle and you'll see it is actually a pair of stars. Mizar's much fainter companion is Alcor. This famous double star is known by some as 'The Horse and Rider'.

Beehive Cluster (M44)

Messier 44, also dubbed the Beehive Cluster or Praesepe, is an open star cluster in the middle of the constellation of Cancer, the Crab. A smudge to the naked eye, binoculars and telescopes reveal it is a group of almost 1,000 stars, one-and-a-half-times as wide as the Moon. The easiest way to find Messier 44 is by drawing a line from Pollux in Gemini to Regulus in Leo.

Sickle of Leo

'The Sickle' is the name given to the stars representing the head of Leo, the Lion. It looks like a back-to-front question mark in the sky, or the hook of a coat hanger. Since it is close to the ecliptic, bright planets can often be seen in or near the Sickle.

Arcturus (Alpha Boötis)

Shining at magnitude -0.05, red giant Arcturus is the fourth-brightest star in the sky and the brightest in the Northern Celestial Hemisphere. It is just over 36-light-years away, and is found by following the curve of the Big Dipper's handle.

Regulus (Alpha Leonis)

Blue-white Regulus is 79-light-years away and is the 21st-brightest star in the sky at a magnitude of 1.35. In Latin its name means 'Little King'. Although the naked eye sees Regulus as a single star, it is actually two stellar pairs orbiting each other, which can be split into two by amateur telescopes.

How to...

Split double stars

Approximately 50 per cent of all the stars in the night sky are double or multiple systems. Here's how to get the best resolution of their components

PHILIP'S
NIGHT SKY ATLAS
THE MOON, PLANETS, STARS AND DEEP SKY OBJECTS

You'll need:

- ✔ Double star catalogue
- ✔ Red torch
- ✔ Telescope
- ✔ Binoculars

Some 'double stars' are two stars which orbit a common centre of gravity in a never-ending dance. Others, however, by a chance line of sight effect, appear very close to each other, even though they may be several light years away in reality. There are hundreds of these peppered throughout the night sky, and many of them are within the grasp of even a small amateur telescope. Some, in fact, are even visible to the naked eye, providing that you have good eyesight and a dark sky in which to observe them.

Most double stars, though, require a telescope to be able to split them; that is, to be able to resolve each star in the system as an individual object. This can vary in difficulty due to a number of factors, including how close each star is to the other - both physically and apparently - as well as how bright each component of the double system is. There is also the usual obstruction of clouded or light-polluted skies, and the aperture size of your telescope to consider. Usually it's the larger the aperture the better, but not always. Some double stars which are considered 'wide' can often look better in smaller telescopes at a lower power.

Splitting the components of these systems can be fun and interesting, as many of them have stars of contrasting colour, such as Albireo in Cygnus the Swan, which adds another layer of interest to observing them. You do need to appreciate just what your telescope is capable of in terms of its resolving power to have a realist chance of splitting some of the closer double stars, though.

Weather and seeing conditions can also play a part in just how well you can separate the stars. It's as well to start with easy-to-see double stars, of which there are many, and work your way towards the closer, and therefore harder, ones.

There are many lists of double stars available on the Internet and elsewhere, including observing programmes if you would like to take part in them. This can be a fun and rewarding subject to enhance your appreciation of the night sky. You can even get involved with more serious observing through programmes run by the British Astronomical Association (BAA) and the American Association of Amateur Astronomers (AAAA).

Start with the stars Mizar and Alcor, the naked-eye double in the handle of Ursa Major (The Big Dipper), move on to a few binocular double stars and then have a go at splitting some with your telescope. Above all though, have fun!

Tips & tricks

Start with naked-eye doubles

There are a handful of naked-eye double stars in the night sky, so test your visual acuity with them.

Follow up with binoculars

Even small binoculars will increase the number of double stars visible.

The larger the aperture, the better

You can use almost any size of telescope to see double stars, but for tight-knit double stars you will need a large aperture to split them well.

Make a note of magnification

Higher magnifications are usually good for splitting double stars, but this does depend on how far apart they are.

Know your resolving power

How close the stars are that you can split really depends on the aperture size of your telescope. See the next page on how to work this out.

Pushing your telescope to the limit

Here's how you can work out which stars you can comfortably resolve...

Divide the diameter of your telescope's lens or mirror in millimetres by the number 120, so an aperture of 90 millimetres divided by 120 equals 1.33. This number is the arc seconds between two stars which your telescope can make out as individual objects. Double stars which are further apart will be split, but stars which are closer than 1.2 seconds of arc separation will not.

Send your photos to
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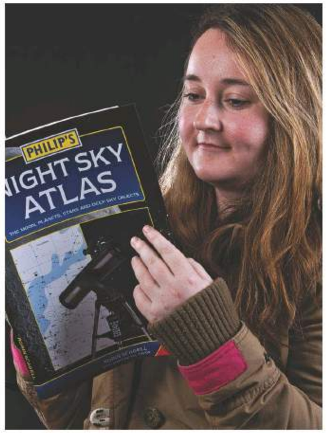
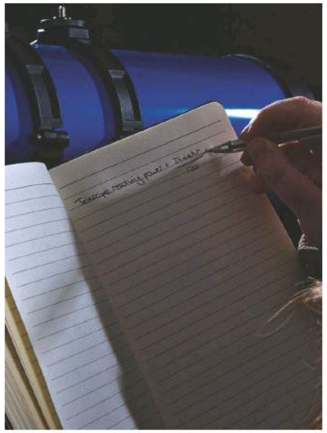


1 Train your eyes

Begin your double-star observing by seeing just how well you can split naked-eye doubles using no optical aid. You should refer to a star map if you're unsure which are visible to the naked eye.

2 Upgrade to binoculars

Seek out a list of double stars that are visible using binoculars with magnifications of at least 10x50. When observing, make sure you keep your hands steady.



3 Work out your resolving power

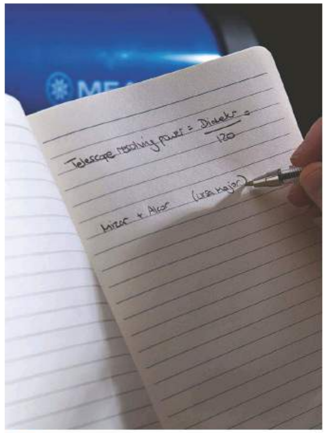
Work out the resolving power of your telescope using the simple formula explained above. Knowing this factor means that you're able to push your instrument to the limit.

4 Begin with wider doubles

Start with double stars that are more widely spaced first to help train your eye and brain. This will enable you to work up to the more 'tight-knit' ones by showing you what to look out for.

5 Experiment with eyepieces

Use two or three different eyepieces to see which is best for resolving the double star you are looking at. Views that demonstrate the best clarity and resolution are the best.


Telescope resolving power = Diameter / 120
Mizar + Alcor (Ursa Major)

6 Notebook

Note down the name or number of the stars you have seen, component colours and how far apart they are. This will reveal the type of stars you're observing.

Deep sky challenge

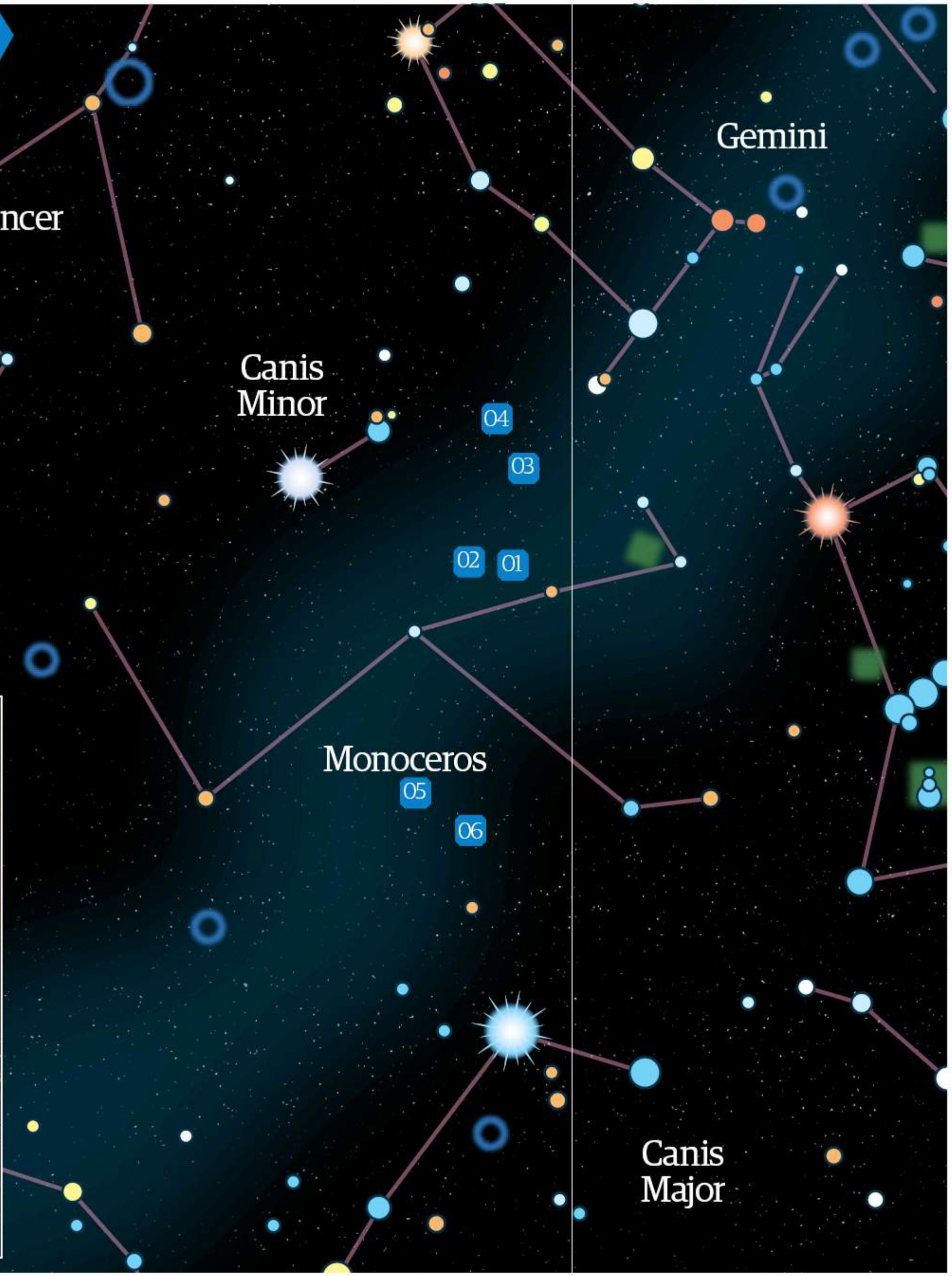
Observe the unicorn's sparkling treasures

Winter skies are rich in deep-sky objects for your telescope to hunt down and enjoy. Here are just a select few...

Just to the east of the constellation of Orion (the Hunter) is a dimmer constellation called Monoceros (the Unicorn). Although none of the stars that make up the group are particularly bright, this constellation sits in the band of the Milky Way, and is therefore rich in nebulae and star clusters.

It contains some fairly well-known objects such as the Cone Nebula, the more famous Rosette Nebula, and Hubble's Variable Nebula; this is a rich region of the sky to go exploring with a telescope of almost any size.

Christmas Tree Cluster (NGC 2264)



Hubble's Variable Nebula (NGC 2261)

Seagull Nebula (IC 2177)

1 Rosette Nebula (NGC 2238)

The Rosette Nebula (NGC 2238) is a tricky nebula to see visually. However, with the right equipment, namely a larger aperture and very good observing conditions, it opens up to reveal a fine cluster at the heart of luminous gas and dust.

2 Satellite Cluster (NGC 2244)

You can pick up this loose collection of stars with a pair of binoculars, but for more comfortable views, use a small telescope to pick out the gaggle of blue stars that shine at a collective magnitude of 4.4.

3 Hubble's Variable Nebula (NGC 2261)

You'll need a four-inch telescope in order to spot this mysterious-looking object. The nebula itself is like a hollow shell, but see if you can spot light and dark knots using a high-power eyepiece.

4 Cone Nebula (NGC 2264)

Since the Cone Nebula is a challenging target given its feeble glow, dark skies and a large-sized telescope are needed to pick it out. The nebula lies in the southern portion of the Christmas Tree Cluster (NGC 2264).

5 Heart-Shaped Cluster (Messier 50)

This is an open star cluster that, as its name suggests, appears to have the shape of a heart. A small telescope will reveal the cluster's heart shape, while larger apertures will tease out blue-white, yellow and orange stars.

6 Seagull Nebula (IC 2177)

This nebula is best seen in large-aperture telescopes, and a UHC filter can help increase the contrast. This H II complex lies on the border of Monoceros, as well as Canis Major, covering over three degrees of sky.

© Will Tirion; ESO; Judy Schmidt

How to...

Observe very faint deep-sky objects

No matter the size of your telescope, some targets can be a struggle to capture. Here's how to push your instrument to its limit...

You'll need:

- ✔ Telescope
- ✔ Red torch
- ✔ Detailed star chart
- ✔ Filters (optional)

There are numerous objects, such as nebulae and galaxies, that can be really tricky to see through a telescope, even though you think your instrument should be able to show them to you. If you can't see them, there are many factors that come into play which may be making it difficult, and there are some 'tricks of the trade' which you can use that can really help.

Atmospheric conditions are among the most variable, and potentially problematic when it comes to seeing those really faint objects. Known as 'seeing', differing layers of moving air at different temperatures can smear out the light from objects, rendering some nearly invisible. The only thing you can do then is try another night. Bright moonlight is another issue which can drown out faint objects and keep them from view, so again, wait until the Moon is not too bright in the sky. There are other problems which are more intermittent, but some of these are more easily overcome, and there are things you can do yourself that will greatly improve your chances of seeing those elusive faint fuzzies. Even simple things like keeping warm on a cold night can help. It can be difficult to concentrate on a faint galaxy when your teeth are chattering! It's also best to avoid drinking alcohol or caffeine before or during observing.

The use of 'averted vision' is an old trick which can really help. This is where you don't look directly at an object, but rather to the side of it. This puts the light onto the most sensitive part of your retina, and it works really well. Filters, too, can make a difference. You can use ordinary coloured filters for some objects, as this can help filter out some elements of light pollution, but it is better to use more specialist filters to do this job. Known as anti-light pollution filters, they are available from most good telescope dealers. You can also use filters such as the Ultra High Contrast (UHC) or Oxygen 3 (OIII), although these work best with specific types of object. OIII filters for example, work well on planetary nebulae. Using a slightly higher magnification can help as well, as this helps to increase the contrast of the object against the black sky. You need to use your judgment here though. There are several things that can help you glimpse objects you perhaps thought were impossible, so good hunting!

Tips & tricks

Get a detailed star chart

Use a detailed star chart, clearly stating the magnitude of fainter objects. Knowing their brightness will reveal if it's possible to see them in your scope.

Use a red torch

Help preserve your dark-adapted vision by using a red torch to read your star chart. Red light, unlike normal white light, does not affect the pupils.

Check your telescope's specifics

Know or work out the limiting magnitude of your telescope. There's no point looking for objects your scope just can't show you.

Go for a higher magnification

Providing you can fit the object into the field of view, a slightly higher magnification will help increase the contrast with ease.

Make the most of averted vision

By not looking directly at an object, but just slightly away from it, you'll be able to see more diffuse deep-sky targets.

Push your telescope to the limit

Knowing what your telescope can do, whatever its size, and how to use it to best effect, will give you an advantage.

Work out what your telescope is capable of

There's no point looking for an object your instrument can't see - know its observing capabilities before you set out

There are some places online where you can input some details of your scope and skies to work out what magnitude you can see. This will help you pick out suitable targets. If the object you are looking at is still proving difficult, try using a filter or averted vision, or even gently tapping the telescope tube - the movement can cause the eye to respond, as we have evolved to see things in motion.

Send your photos to
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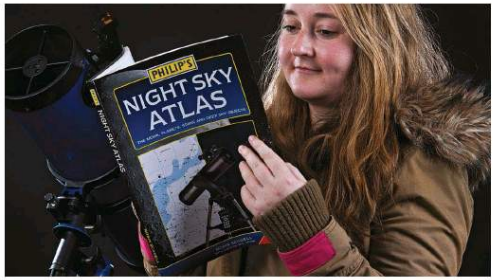


1 Select your targets wisely

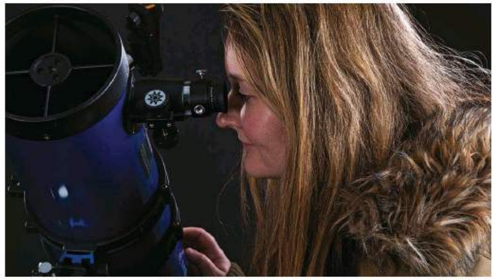
Choose a few objects fairly high in the sky which are within the grasp of your telescope. You should use a night sky guide to plan your evening.

2 Get dark-adapted eyes

Allow your eyes to get accustomed to the dark - it can take up to half an hour for your pupils to respond to low light. Use a red torch for reading.

3 Choose the right eyepiece

Carefully select an eyepiece that won't push your telescope beyond its observing capabilities - otherwise you will get a blurred image.

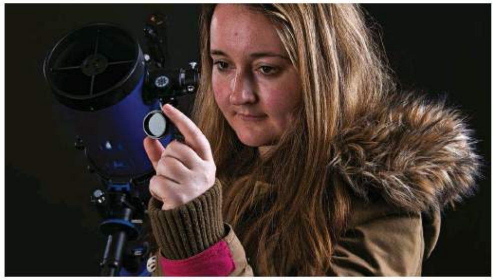


4 Make the most of averted vision

If you can't see the object, look away from the centre of the field of view and see if you can detect it using your peripheral vision.

5 Be sure to breathe!

A couple of deep breaths (no more than that!) can help oxygenate your brain, which in turn helps your visual acuity.



6 You might need to use filters

If you still can't see it, try using a suitable filter or try to observe your target another night, as atmospheric transparency might be the issue.

The Northern Hemisphere

The New Year has arrived with some of the very best night sky targets, studded in long winter nights

Whether you just got your first telescope for Christmas or you've long been observing, there are some wonderful targets to seek out in the New Year.

Orion (the Hunter) and Taurus (the Bull) remain prominent in the sky, offering splendid sights including red supergiant Betelgeuse, brilliant blue-white Rigel, the Pleiades star cluster (Messier 45), orange giant Aldebaran and of course, the Crab Nebula (Messier 1). Look southeast and you'll spot a celestial Great Dog: a seemingly basic-looking pattern of stars, Canis Major features several binary systems and supergiant stars. It's also home to open cluster Messier 41, which contains an impressive collection of red giants and white dwarfs, not too far from 'Dog Star' Sirius.

Using the sky chart

This chart is for use at 10pm (GMT) mid-month and is set for 52° latitude.

01 Hold the chart above your head with the bottom of the page in front of you.

02 Face south and notice that north on the chart is behind you.

03 The constellations on the chart should now match what you see in the sky.

Magnitudes

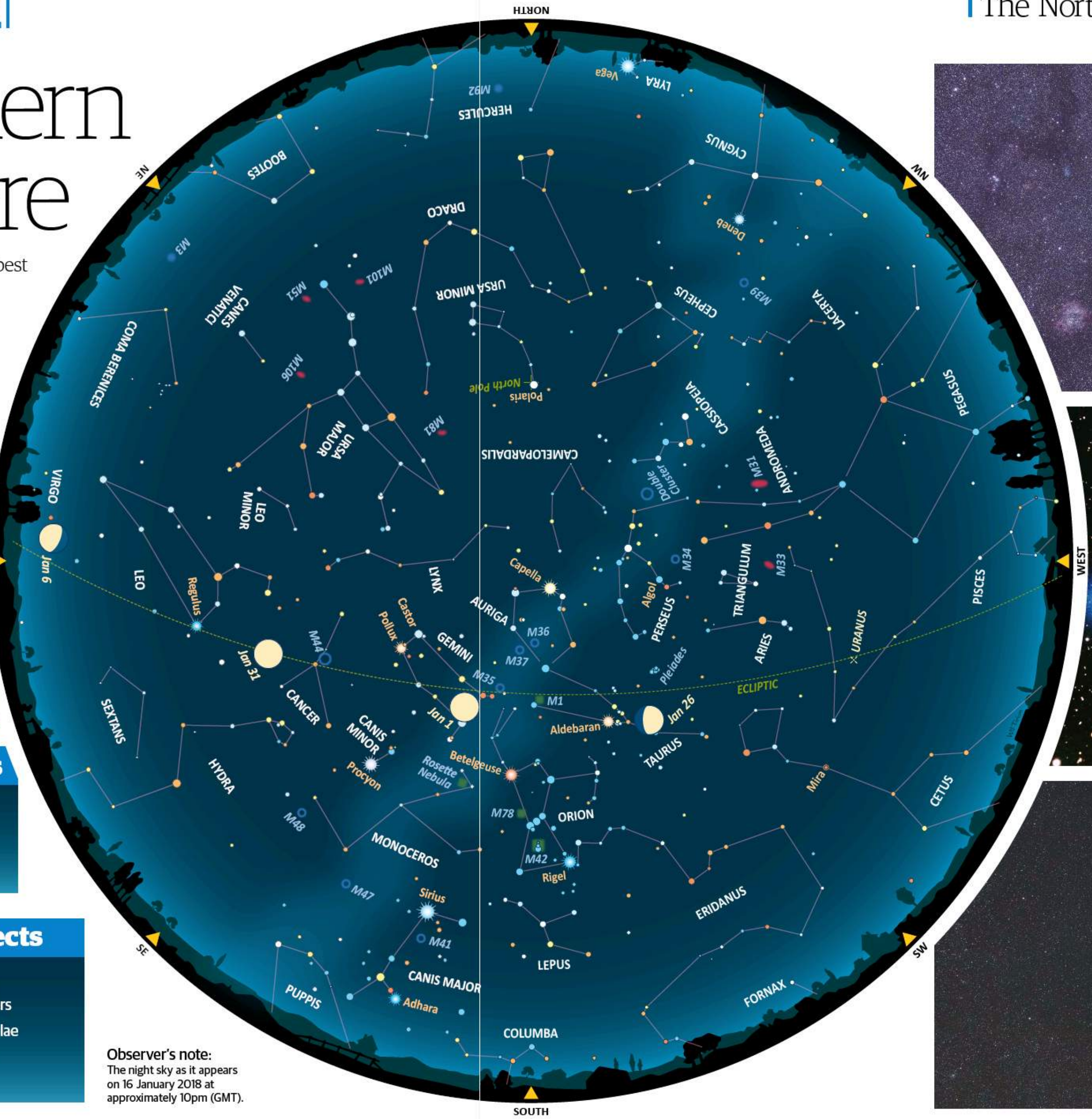
- Sirius (-1.4)
- -0.5 to 0.0
- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- Fainter
- Variable star

Spectral types

O-B	G
A	K
F	M

Deep-sky objects

- Open star clusters
- Globular star clusters
- Bright diffuse nebulae
- Planetary nebulae
- Galaxies



Observer's note:
The night sky as it appears on 16 January 2018 at approximately 10pm (GMT).

Betelgeuse and the Rosette Nebula (Caldwell 49)

Pleiades (M45)

Sirius and Messier 41 (lower left), Messier 50 (upper left) and NGC 2360

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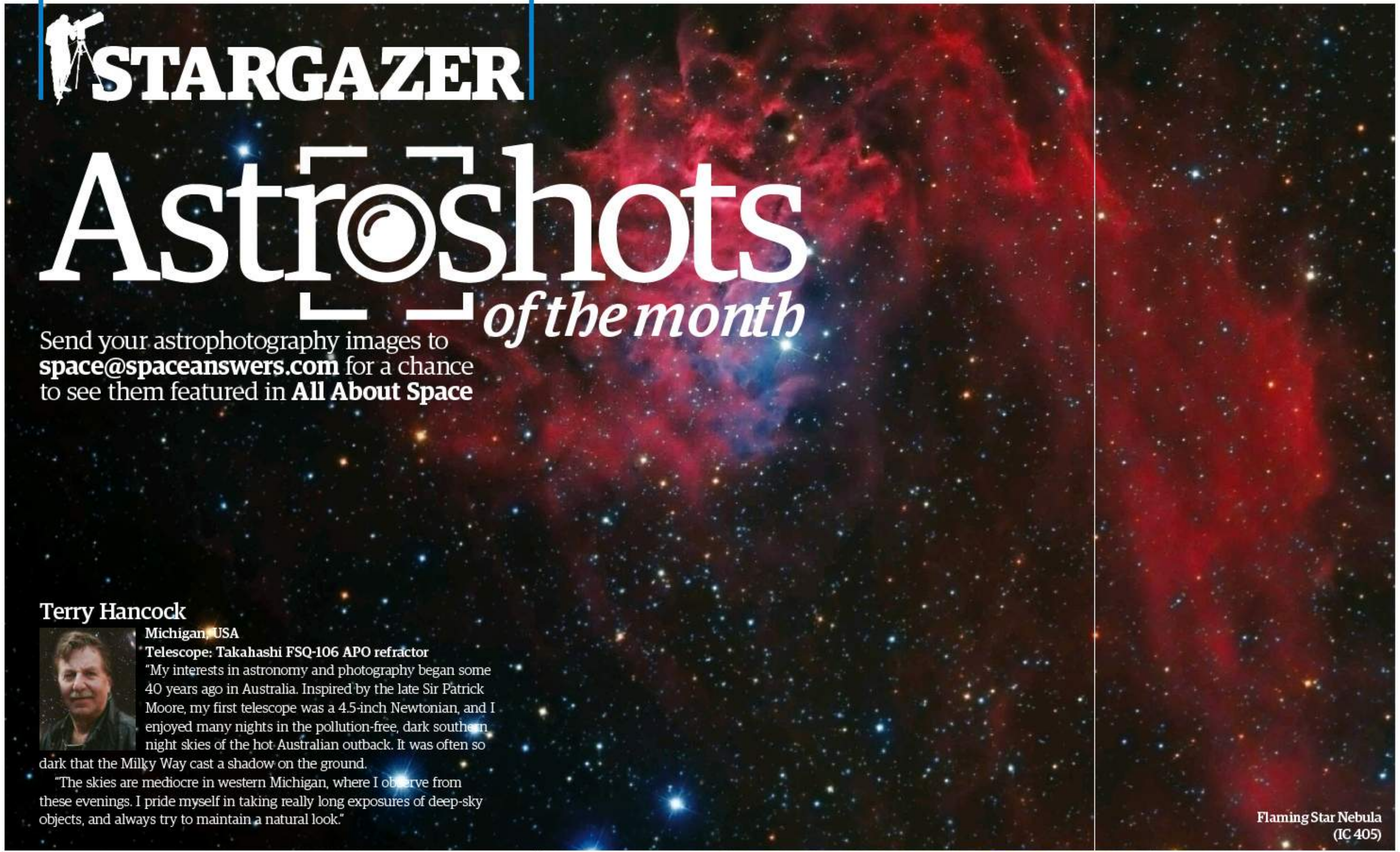
Astroshots of the month

Send your astrophotography images to **space@spaceanswers.com** for a chance to see them featured in **All About Space**



Terry Hancock

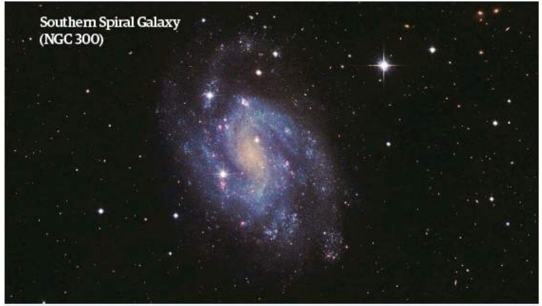
Michigan, USA

Telescope: Takahashi FSQ-106 APO refractor

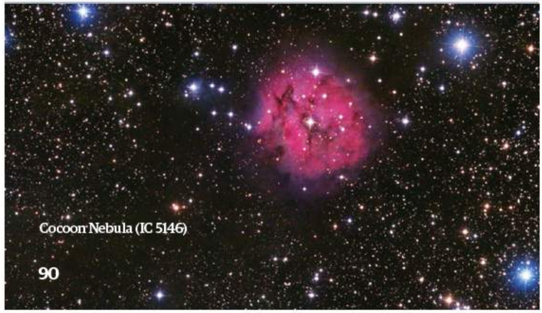
"My interests in astronomy and photography began some 40 years ago in Australia. Inspired by the late Sir Patrick Moore, my first telescope was a 4.5-inch Newtonian, and I enjoyed many nights in the pollution-free, dark southern night skies of the hot Australian outback. It was often so dark that the Milky Way cast a shadow on the ground.

"The skies are mediocre in western Michigan, where I observe from these evenings. I pride myself in taking really long exposures of deep-sky objects, and always try to maintain a natural look."

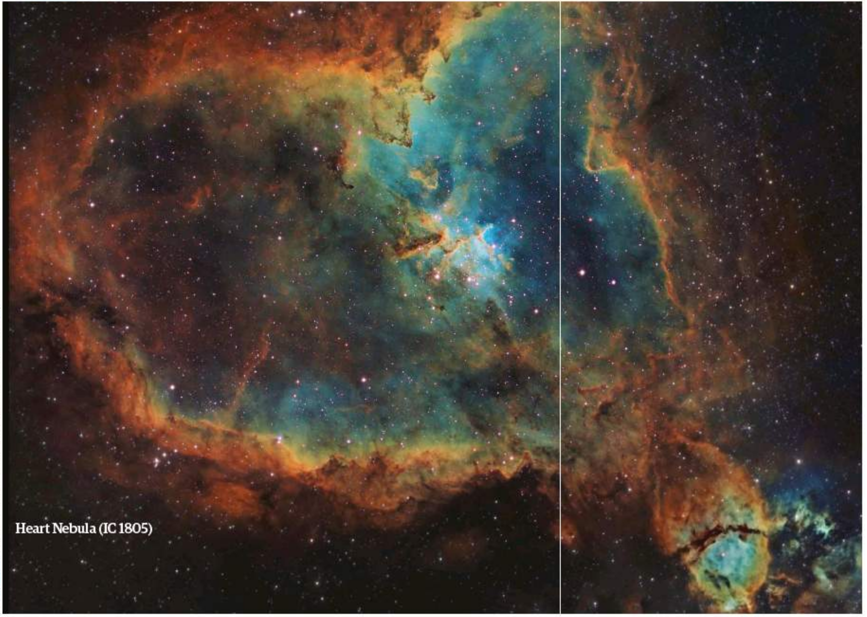
Flaming Star Nebula (IC 405)



Southern Spiral Galaxy (NGC 300)



Cocoon Nebula (IC 5146)



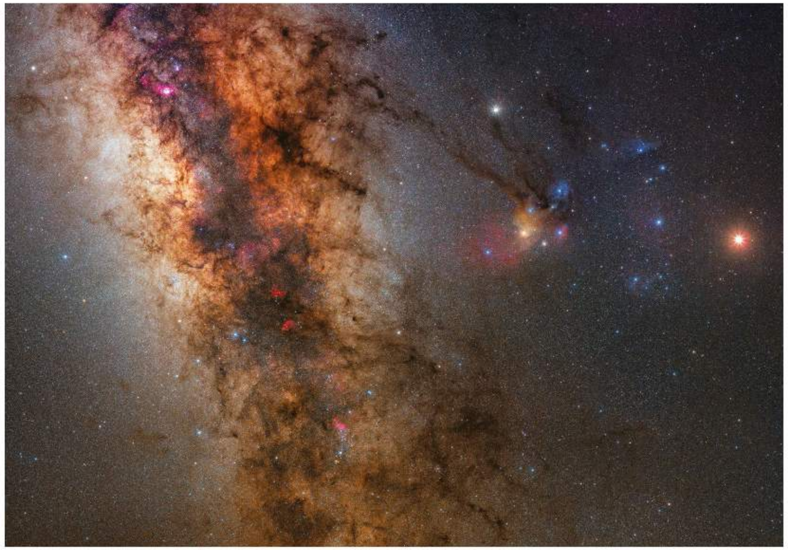
Heart Nebula (IC 1805)

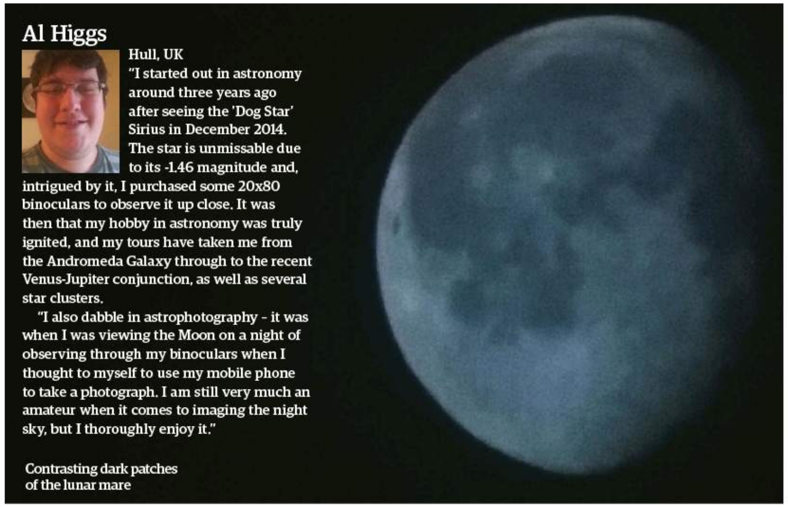
Ehsan Rostamizadeh

Kerman, Iran

"Taken in June from Bidkhoun village in Kerman, I managed to capture Saturn and Mars 'visiting' the dusty, star-filled path of the Milky Way. Within this shot of our galaxy you can see bursts of pink and blue, these regions are where stars are being born.

"To capture the scene, and ensure that I achieved as much as detail as possible, I used a Canon 40D DSLR attached to a equatorial mount."





Al Higgs

Hull, UK

"I started out in astronomy around three years ago after seeing the 'Dog Star' Sirius in December 2014. The star is unmissable due to its -1.46 magnitude and, intrigued by it, I purchased some 20x80 binoculars to observe it up close. It was then that my hobby in astronomy was truly ignited, and my tours have taken me from the Andromeda Galaxy through to the recent Venus-Jupiter conjunction, as well as several star clusters.

"I also dabble in astrophotography - it was when I was viewing the Moon on a night of observing through my binoculars when I thought to myself to use my mobile phone to take a photograph. I am still very much an amateur when it comes to imaging the night sky, but I thoroughly enjoy it."

Contrasting dark patches of the lunar mare

Send your photos to... @spaceanswers @ space@spaceanswers.com

Omegon Ritchey-Chrétien Pro 154/1370

Broaden your astronomical horizons with an instrument that is capable of providing incredibly crisp and clear views

Telescope advice

Cost: £415 (€465)
From: Astroshop.de
Type: Ritchey-Chrétien
Aperture: 6"
Focal length: 54"

Best for...

- Intermediate
- Advanced astrophotography
- Planetary viewing
- Deep-sky objects
- Medium budget

Astrophotography often starts by simply attaching a smartphone to your telescope's eyepiece or clamping a DSLR to the eyepiece. However, if it's a hobby you're keen on perfecting the art of, there will come a time when you realise you have surpassed your beginner or equipment, and it's time to upgrade. When that time has come, it is worth considering Astroshop's own Omegon Ritchey-Chrétien (RC) Pro 154/1370 telescope. Although you are paying for just the telescope tube, it certainly takes care of an astronomer's needs when imaging the night sky. Being a specialised adaptation of the conventional Schmidt-Cassegrain (SC) telescope, the RC telescope provides an incredibly sharp and crisp view of celestial objects, making it ideal for picking out details in an array of both planetary and deep-sky objects.

The telescope is a reasonable size, with a length of 485mm (19") and a diameter of 191mm (7.5") and, with a weight of 5.5 kg (12 lbs), it is easily transportable and not a hassle when on the move. Encased within the sturdy steel tube is the specialised RC structure, providing an aperture size of 154mm (6") and a focal length of 1,370mm (54"), boasting a focal ratio of f/9 - this is considered a medium focal ratio, as it provides both a reasonable field of view and high-powered views (depending on the eyepiece). The telescope tube also has a fitted finderbase, allowing you attach your favourite finderscope to make finding your target a much easier process Built onto the instrument is a dovetail rail, which seems fairly universal among telescopes now, meaning you can attach the Omegon Ritchey-Chrétien Pro to an array of telescope mounts. For the sake of astrophotography, we would suggest staying away from an alt-azimuth mount, as it makes tracking an object as it moves across the night sky a much harder task, causing issues when it comes to imaging.

The full contents of this package are minimal compared to a beginner's telescope setup: it contains the telescope, a 2" to 1.25" eyepiece adapter and spacers (a 50- and two 25-mm focuser extension sleeves). But let's not forget, this package is catering to the more advanced astronomers, which also ensures you are purchasing optics capable of unveiling deep-sky objects, which are faint and difuse in stunning clarity. A welcomed feature of the package is the 1.25" adapter, as it means you're not constrained to just using 2" eyepieces when using this scope.

Out in the field, the optics of the telescope proved to be very impressive. It is abundantly clear that a lot of thought went into the design to ensure an astrophotographer is well-equipped for a reasonable price. As mentioned previously, the RC structure is a variation of the classic SC models. The difference is that the RC includes a hyperbolic primary and secondary mirror, this corrects for any aberration through the eyepiece, ensuring that it provides the sharpest views possible. This structure is primarily used in major telescopes as well, such as the Subaru Telescope at the Mauna Kea Observatory, ensuring it's the best tool for the job of imaging the cosmos. Without the need for a corrector plate, this means the telescope has an open design to it and as a consequence, the mirrors can be cooled by the cold air of the outdoors, instead of being encapsulated within the telescope and being heated. However, this open design means the mirrors are more likely to be contaminated, so it's important to maintain an internally clean telescope for optimal use.

The long winter nights provided a medley of fantastic sights to test the esteemed optics of the Omegon Ritchey-Chrétien Pro. We initially began observations with a Plössl 25mm eyepiece with a magnification of 55x. With the 25mm eyepiece attached and we pointed the telescope towards the famous Orion Nebula (Messier 42), this provided a wonderful combination of starlight illumination clouded by interstellar dust. The view of the Orion Nebula was highly enjoyable; not only was it clear and crisp, but it didn't blur towards the edges in our field of view. After slewing across the sky to Bode's Galaxy and the Cigar Galaxy (Messier 81 and 82) in Ursa Major, we achieved crisp and clear views towards the outer edges of the objective lens.

When using the Omegon Ritchey-Chrétien Pro, you should use a motorised mount that can track the movement of a celestial object, or at least an equatorial mount with an attached motor drive. This is recommended for astrophotography with long-period exposure times, as the object won't move within the field of view and cause blurring to the image. As this is considered a medium focal ratio, we discovered that it's possible to image luminous objects, such as the Moon or planets. As these are very bright though, we found that a long exposure time won't be necessary, as the tracking of the object is negligible. Tracking came in handy when we were imaging deep-space objects such as Messier 78, a reflection nebula that's part of the Orion Molecular Cloud Complex, also home to the Orion Nebula, but Messier 78 is a much smaller and much less luminous version of its celestial companion. Messier 78 requires a long exposure time in order to collect more of its distant light, but we still got a fantastically sharp and crisp view for a short exposure time. By imaging an object such as this using different colour filters and merging them on a computer software such as Adobe Photoshop, a truly striking and colourful image of Messier 78 was created with ease. We also suggest that if you cannot get to a dark-sky region, you should consider purchasing a City Light Suppression (CLS) filter, which will block out some light pollution and allow the light from the nebula to continue through to the camera's CCD.

A great telescope for an upgrade to improve upon your astrophotography skills, the Omegon Ritchey-Chrétien Pro allows you to explore a roster of deep-sky objects from season to season at a reasonable price. We feel that this telescope is much too advanced for a beginner, and is much better suited to an intermediate astronomer that has grown beyond their original kit. If you are planning to progress much further in the hobby of astrophotography, then this observing-imaging combo is certainly worth a look.

"The optics of the telescope proved very impressive"

The supplied spacers (right) allow the astronomer to adjust the position of the telescope's focus

The telescope caters for the most advanced astronomer, with minimal accessories supplied

WIN! ASTRONOMY KIT

WORTH OVER £3,000!

Just in time for a new season of observing, we're offering you the chance to win telescopes, accessories and more

1. Meade LightBridge Mini 130

The LightBridge Mini 130 allows you to set up and share a stargazing experience in seconds. Whether you are camping in the outdoors or relaxing in your backyard, the LightBridge Mini 130 Dobsonian is the ideal 'grab-and-go' telescope, offering easy and portable observation with its removable optical tube. Boasting an impressive 130mm parabolic aperture with a 650mm focal length, the 360-degree swivel mount and a simple point-and-look design make navigating the sky effortless.

2. Meade 15x70 Astro Binocular

Whether the object you are observing is light-years away or perched in a tall tree, Meade's 15x70 Astro Binoculars provide sharp, bright, high-resolution viewing through high-performance fully multi-coated BAK-4 prism optics. With a convenient centre-focus mechanism and flip-up rubber eyecups for eye-glass wearers, Meade Astro Binoculars allow easy, comfortable observation of familiar objects such as the Moon, stars and planets at 15x magnification, opening up the wonders of the night sky to a multitude of users.

3. Meade Series 4000 1.25" eyepiece and filter set

Includes five Meade Series 4000 Plössl Eyepieces in focal lengths of 6mm, 9mm, 13mm, 18mm, and 32mm. All eyepieces feature a standard 1.25" barrel size with a 52-degree field of view and are of a four-element design with premium optical glass. Each also features a soft rubber eye guard for comfort. This complete kit additionally includes a Meade 2x Barlow lens to double the power of any of the included (or any other 1.25") eyepieces. In addition, the collection contains six colour filters to enhance your targets and provide contrast.

To be in with a chance of winning, all you have to do is answer this question:

How many constellations are there in the entire night sky?

A: 60 B: 98 C: 88

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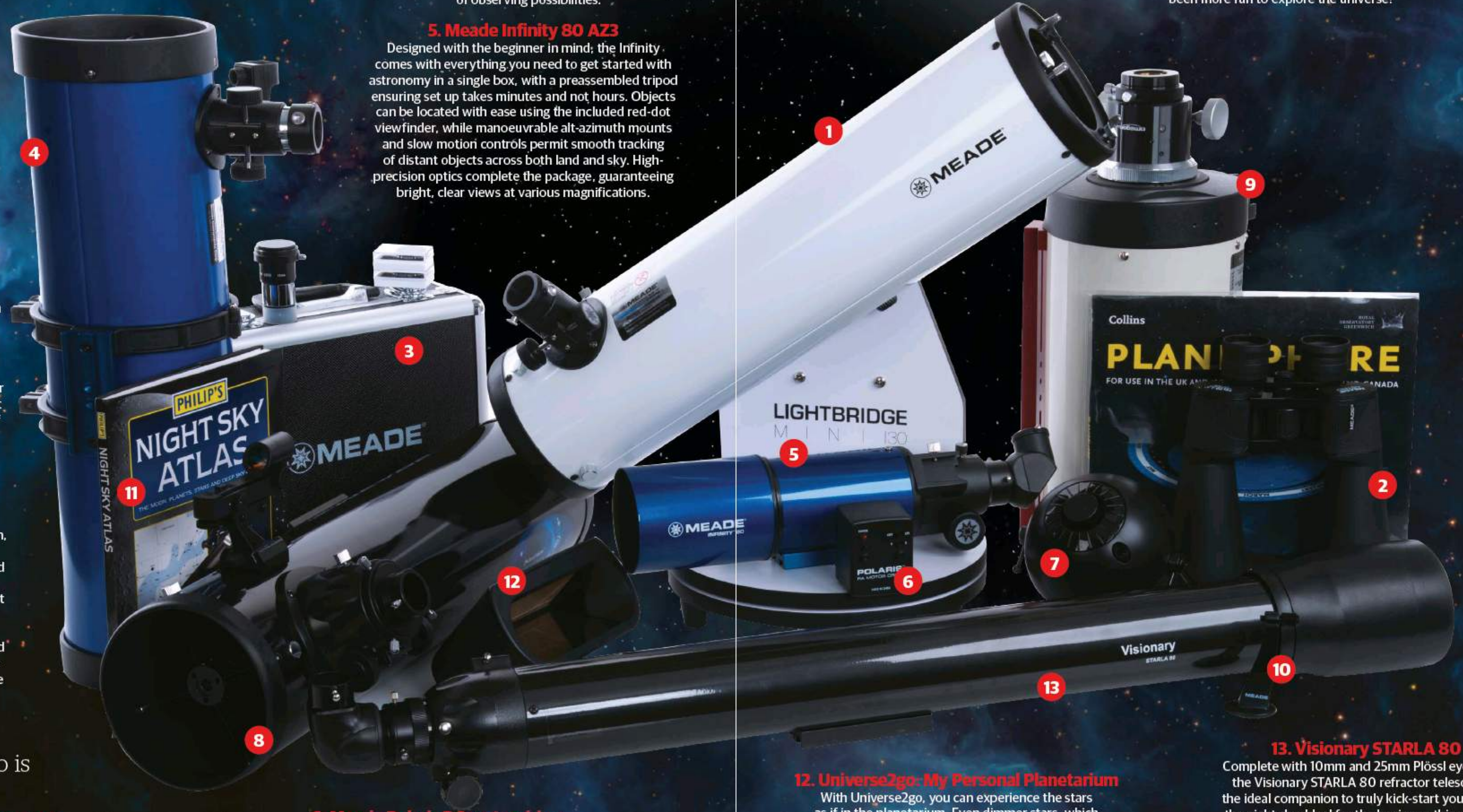
Visit the website for full terms and conditions at **www.spaceanswers.com/competitions**

4. Meade Polaris 130 EQ3

Designed for the intermediate-level user, the Polaris 130mm aperture, 1,000mm focal length Equatorial Reflector Telescope from Meade is designed to take astronomy to the next level by providing a complete set-up for viewing the planets and deep-sky objects like galaxies, star clusters, and nebulae. Three eyepieces provide 25x, 72.2x, and 103x magnifications with a 2x Barlow lens that doubles the magnification of each eyepiece for a wider range of observing possibilities.

5. Meade Infinity 80 AZ3

Designed with the beginner in mind, the Infinity comes with everything you need to get started with astronomy in a single box, with a preassembled tripod ensuring set up takes minutes and not hours. Objects can be located with ease using the included red-dot viewfinder, while manoeuvrable alt-azimuth mounts and slow motion controls permit smooth tracking of distant objects across both land and sky. High-precision optics complete the package, guaranteeing bright, clear views at various magnifications.



6. Meade Polaris DC motor drive

With the motor drive attached and turned on, the telescope can move at the sidereal rate to track any celestial object and keep it centered in the telescopic field. With the variable speed adjustment, you can quickly and easily change the tracking speed to track the Moon, planets or stars. With the Polaris EQ mount properly aligned to the pole, (see telescope instruction manual) the motor drive will keep the object in the field of view for ten to 20 minutes before recentering is required. Direction of tracking is controlled via a convenient N/S switch on the motor housing. Once installed, the RA motor drive may be left permanently attached to the telescope. Requires a single standard 9V battery (included), which will last many enjoyable observing sessions, approximately 40-hours total run time.

7. Sega Toys Homestar Original planetarium

Imagine enjoying the sky full of stars while sitting on your sofa. This dream can become reality with the Homestar Original from Sega Toys. The high-definition planetarium with ultra-bright three-watt LEDs and rotating movement projects the night sky throughout the year. Two interchangeable discs contain the fixed stars in the Northern Hemisphere, and will enable you to observe the night sky or the map of constellations, as well as an integrated shooting star function. The handy timer lets you fall asleep while gazing at the stars, turning off the planetarium automatically.

8. Celestron Astro Fi 130

The Astro Fi 130mm Newtonian is a fully featured telescope that can be controlled with your smartphone or tablet using the free Celestron SkyPortal app. Celestron's SkyPortal app replaces the traditional telescope hand control for a 100 per cent wireless experience. Just hold your smart device up to the night sky. When you find an object you'd like to view, tap the screen. Your Astro Fi telescope automatically slews to the object, while the screen displays information about it. It's never been more fun to explore the universe!

9. Omegon Ritchey-Chretien Pro RC 154/1370 OTA

Are you looking for an excellent telescope for astrophotography? The Omegon Ritchey-Chretien Pro will take you to the next quality level with your astronomy photos. Omegon RC telescopes provide a wide, coma-free field of view – perfect for round stellar images right out to the edge of the field of view. Find out exactly why an RC telescope is the right choice for astrophotography and why the professionals also use them. Tripod and mount not supplied.

10. Meade binocular tripod adapter

The Meade binocular tripod adapter provides a universal quick and secure mount for any tripod-adaptable binoculars to any standard photo tripod, relieving the arms during extended viewing sessions and providing a steady, stable platform for observations. Easy to attach: simply screw the adapter directly on to any quarter-inch compatible tripod and attach the binoculars via the upper screw mechanism for almost-instant set up. Both Porro and roof binocular models can be mounted for convenient, vibration-free viewing. When viewing birds, wildlife or other objects over long periods of time, a pair of binocular would become heavy and uncomfortable in the hand.

11. Phillip's Night Sky Atlas

Philip's Night Sky Atlas can be used anywhere in the world and at any time of the year. With a sturdy, damp-proof binding, it is the ideal choice for the backyard astronomer using binoculars or a small telescope. It contains all the maps you need to learn your way around the night sky, whether you want to find remote galaxies, sketch lunar craters or make estimates of variable stars. Author Robin Scagell explains what you can see, what equipment (if any) you will need and how to make the most of your time under the stars.

Congratulations to David Wiltshire, who is the winner of Celestron SkyMaster 25x100 binoculars

12. Universe2go: My Personal Planetarium

With Universe2go, you can experience the stars as if in the planetarium. Even dimmer stars, which generally remain unseen as a result of large cities and their light pollution, are now visible thanks to the star viewer. Constellations, planets, deep-sky objects and even satellites are observable with explanations on Universe2go. The audio guide features several hours of material, which provides further elucidation to the observed phenomena. The menu is accessed and navigated through head movements, enabling a change in the viewing mode without removing your smartphone from the star viewer. To begin or interrupt the audio guide, focus on the object or gently shake the viewer.

13. Visionary STARLA 80

Complete with 10mm and 25mm Plössl eyepieces, the Visionary STARLA 80 refractor telescope is the ideal companion to truly kick-start your tour of the night sky. Ideal for the beginner, this refractor provides excellent views of night-sky objects, including the Moon, planets and bright deep-sky targets. It's easy to assemble, and the STARLA 80 also comes complete with a tripod and star diagonal as well as a versatile mount.

Courtesy of

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In the shops

The latest books, apps, software, tech and accessories for space and astronomy fans alike

Book How to Understand E=mc²

Cost: £9.99 (approx. $13.00) **From:** Quercus Editions Ltd

Do you know the true meaning of Albert Einstein's most renowned equation: $E=mc^2$? If you don't, there's no need to worry, as this book does a fantastic job of breaking down what it means and why it's so important to our current understanding of the universe.

How to Understand E=mc² is written by Cambridge University doctorate Christophe Galfard, who during his PhD, was supervised by Professor Stephen Hawking. Galfard has created a compact, yet very thorough, publication about the importance behind Albert Einstein's famous equation. By using several funny and relatable analogies, Galfard dissects the father of modern physics' most important work, revealing how it has made us rethink our entire understanding. To explain such an elaborate concept in just 56 pages is impressive, and we were impressed by the fact that it doesn't bury you in mathematical calculations and formulae, which is quite easy to do. It's also not just Einstein that's recognised, as Galfard makes clear references to other important scientists that help contribute and enhance the story of this important and groundbreaking branch of physics.

Accessory Polaris DC Motor Drive

Cost: £50.00 **From:** Hama UK

Ideal for an astrophotographer, the Meade Polaris DC motor drive is capable of tracking the movement of celestial objects in the night sky, which is perfect for long-exposure times. This particular motor drive is limited to the Meade Polaris Equatorial telescopes, ranging from the 70EQ to the 130EQ models. When attached and operational it does a fine job of keeping the chosen deep-sky object within the telescope's field of view – assuming the telescope is constructed and aligned properly.

The motor drive is capable of Northern and Southern Hemisphere tracking, and just above this switch are small plastic knobs that control the rate of automatic slewing. This will set you up perfectly for a night of observing, and you can even leave it on your telescope to make future assembling a quicker process.

This piece of equipment requires a 9V battery (with one already supplied) and is incredibly easy to attach to the telescope, with the adjustment of a simple screw. For all these reasons, the motor drive would be best suited to a beginner in the astrophotography scene, or just an amateur astronomer who wants to watch a certain celestial object the whole night.

App SPAC3

Cost: Free **From:** ESA & RAM

The SPAC3 mobile app was created to inspire, share and encourage the preservation of Earth, which is something everyone can get on board with. This collaborative effort of the European Space Agency (ESA), the ASI Italian Space Agency, Cittadellarte-Fondazione Pistoletto and RAM Radioartemobile has set out to raise awareness of global issues across different social media platforms. They have done this by combining images taken by ESA astronaut Paolo Nespoli – who is currently aboard the International Space Station – with photos from your own smartphone photo library to create some fantastic pictures with a positive purpose.

The app specifies which of the six areas the user wishes to bring into the open: Land, Food, Water, Health, Climate or Transformation. The six goals collectively cover the aims set out by the United Nations for the 2030 agenda to improve the planet we call home with sustainable development. The two images will be merged together along with the symbol for the 'Third Paradise', which presents a strong message of togetherness. Once the images are shared on social media with the tag '#SPAC3', it will become part of a huge interactive mosaic image on the website **www.spac3.earth**.

Software Celestia

Cost: Free (basic version) **From:** www.celestia.space

Celestia is a 3D astronomy program that allows you to travel the universe on your computer. Available in Windows, Mac OS X and Linux it is widely accessible, and it has proved to be a handy program to have on the laptop or desktop of any astronomer. Upon our initial installation, we were given the Earth and an array of stars to search between. For a more in-depth and fulfilled use of Celestia, we recommend that you take the time to install plenty of add-ons, as there are over ten gigabytes of free extensions available in the 'Motherlode'. A number of different objects can also be included to bring a more extensive and engaging range of celestial views. These add-ons include plenty of Solar System objects, such as planets, asteroids, comets and spacecraft.

"Celestia allows you to travel through the universe on your computer"

Eugene Parker

His work in the field of solar physics changed our understanding of the Sun

Parker was awarded the National Medal of Science in 1989

© Janandd

Eugene Parker is an American astrophysicist that has dedicated his life's work to understanding the elusive and volatile nature of our Sun. His work as a professor at the Enrico Fermi Institute at the University of Chicago, where he still currently resides, changed the way we see the influential ball of burning gas that sits at the centre of our Solar System. Parker's accomplishments in the field are the reason why NASA have named the 2018 Solar Probe after him, making it the first time the organisation have named a spacecraft after a living individual.

Born on 10 June 1927 in Houghton, Michigan, United States, Parker also received his Bachelor of Science degree in physics from the Michigan State University in 1948. He then went on to gain his Ph.D. from the California Institute of Technology (Caltech) in 1951, and before long he was teaching at the University of Utah. It was in 1955 where his extensive and fruitful career at the Enrico Fermi Institute began.

In 1958, Parker presented a paper titled "Dynamics of the interplanetary Gas and Magnetic Fields". This paper suggested that stars, including our Sun, emit vast amounts of energy in a complex system of plasma, magnetic fields and energetic particles known as solar winds. These winds are the driving force behind the energetic particles that permeate throughout the Solar System, but it wasn't until roughly 50 years later that this could actually be proven.

> "NASA has also awarded Parker by naming their revolutionary solar probe after him"

In the late 20th and early 21st century, there was a deployment of space observatories dedicated to observing the nature of the Sun. For instance, the joint NASA and European Space Agency spacecraft, the Solar and Heliospheric Observatory (SOHO), which had a payload of 12 instruments dedicated to measuring different aspects of the Sun's behaviour.

The evidence provided from these observatories is what led to Parker being awarded the prestigious Kyoto Prize for Lifetime Achievement in Basic Science in 2003. This is Japan's highest private global award that has also acknowledged past astronomers like Jan Oort and Edward Lorenz.

Another theory Parker proposed explains the fierce and unexpected heating of the Sun's outermost region, known as the corona. The corona defies the laws of physics, and no one could explain why the corona was incredibly hotter than the surface of the Sun. Parker suggested that small hot solar explosions - referred to as nanoflares - occur regularly, creating this cocoon of plasma.

It's because of these original, intelligent and esteemed pieces of work that Parker has filled an impressive award's cabinet. Some of his awards include the James Clerk Maxwell Prize, the Chapman Medal and the admirable National Medal of Science, which was awarded to him by US President George H. W. Bush in 1989. NASA has also awarded Parker for his scientific achievements in solar physics by naming their revolutionary solar probe after him, which is scheduled for launch in mid-2018. The Parker Solar Probe will probe the outer corona, making it the first-ever mission to 'touch' the Sun.

All About Space

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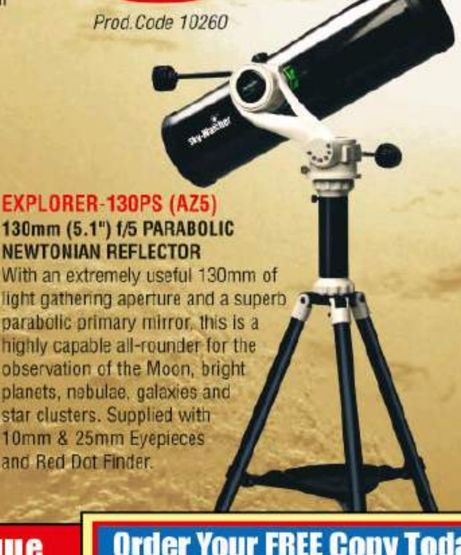

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